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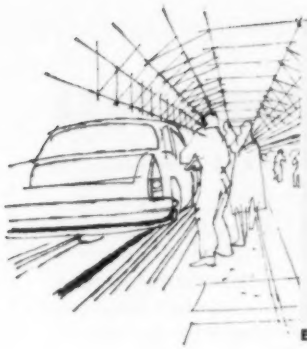

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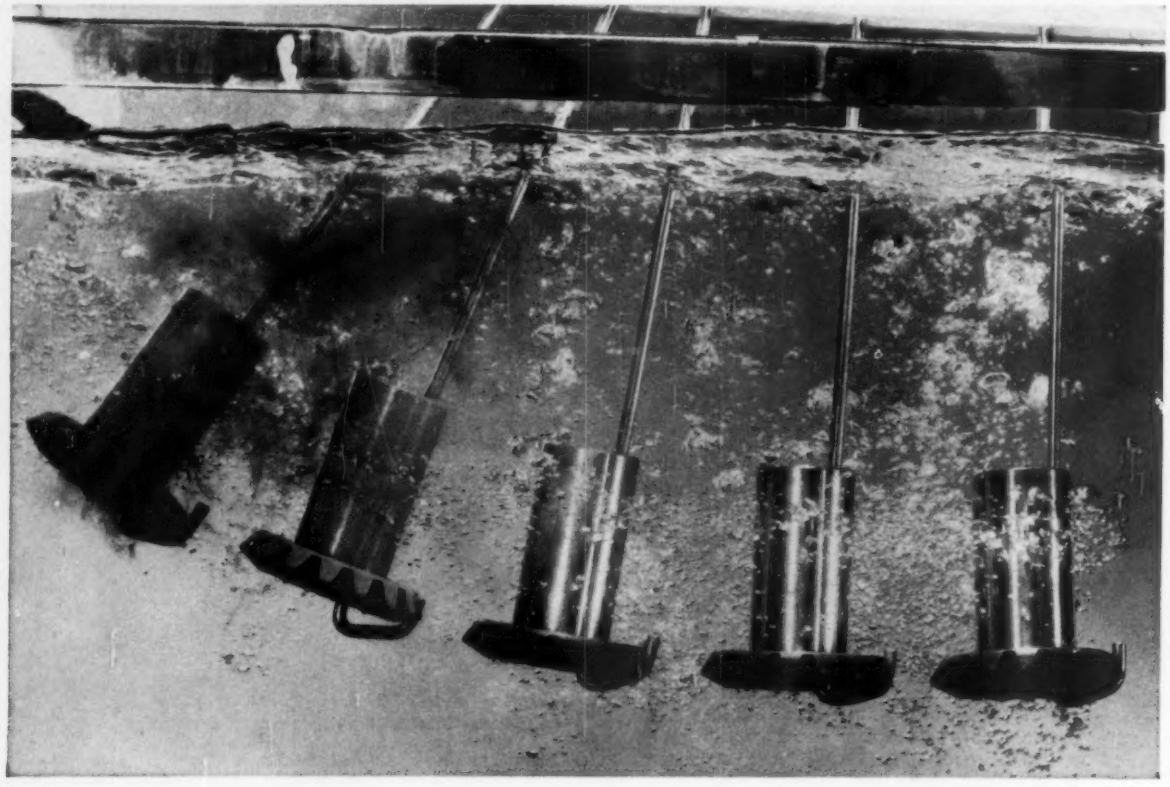

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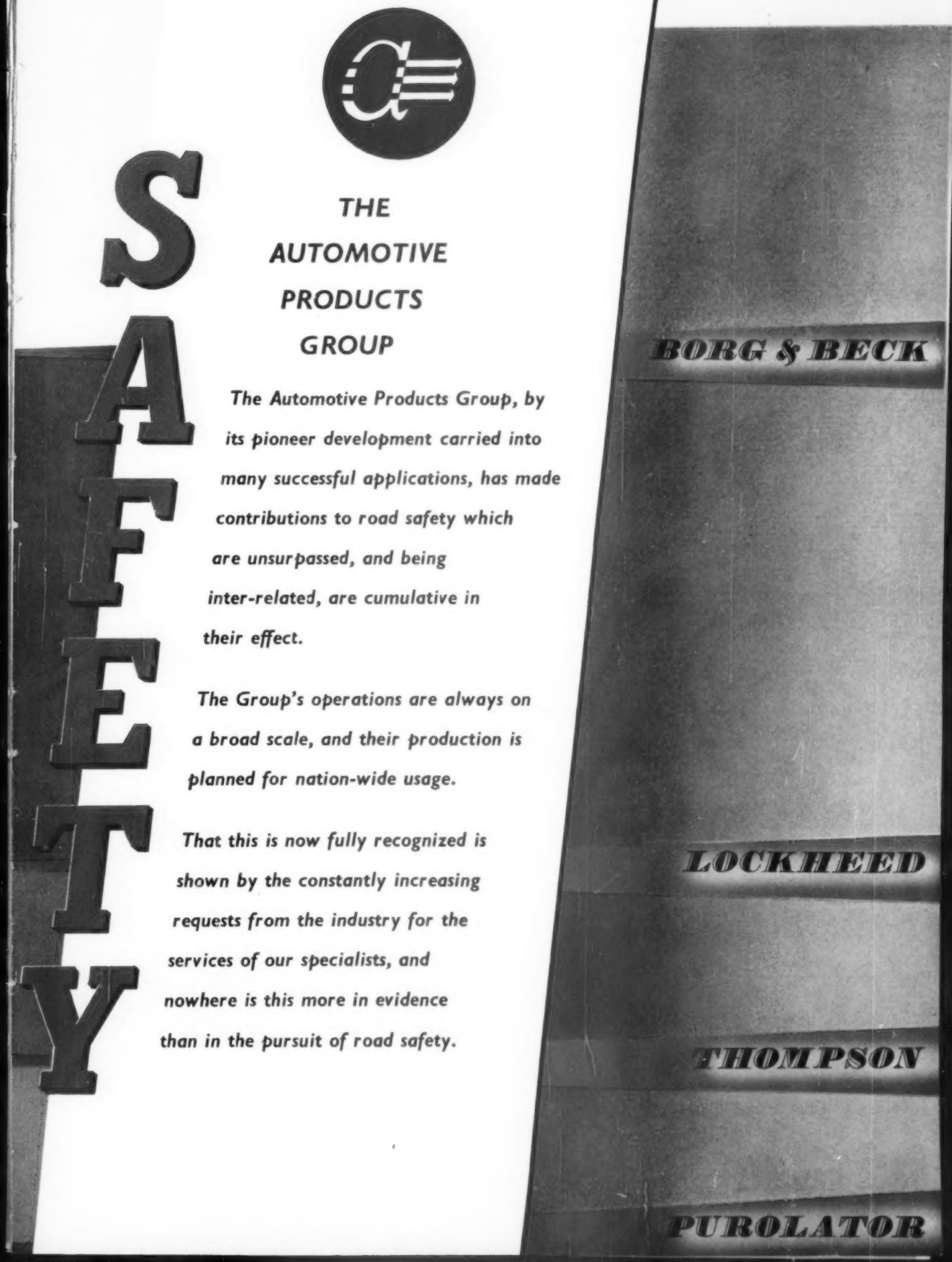
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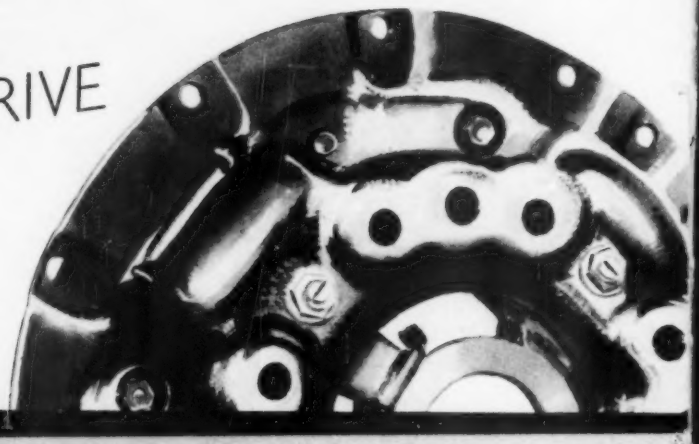

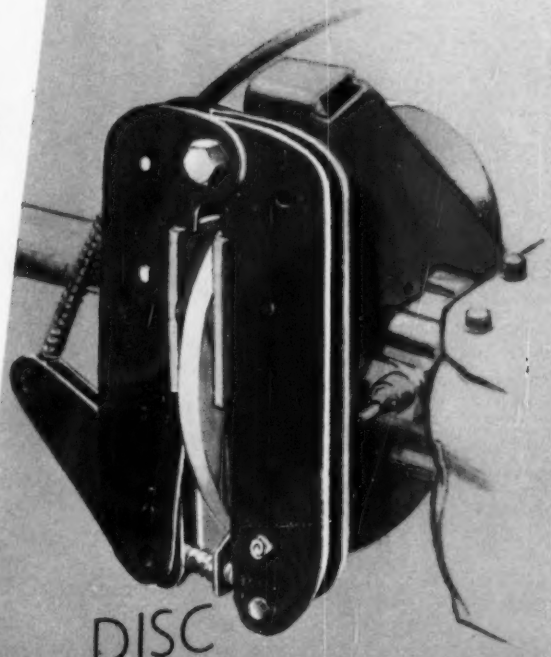

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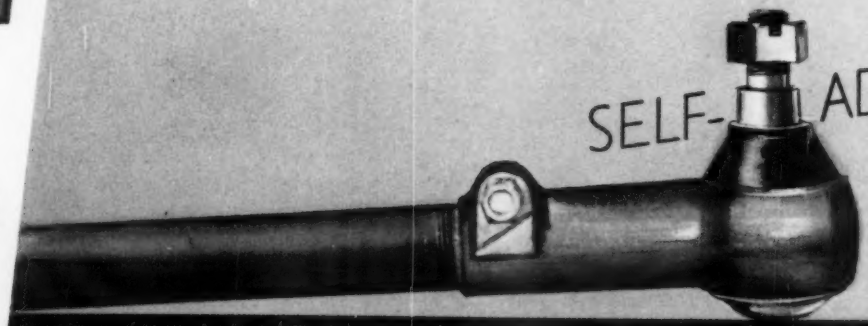
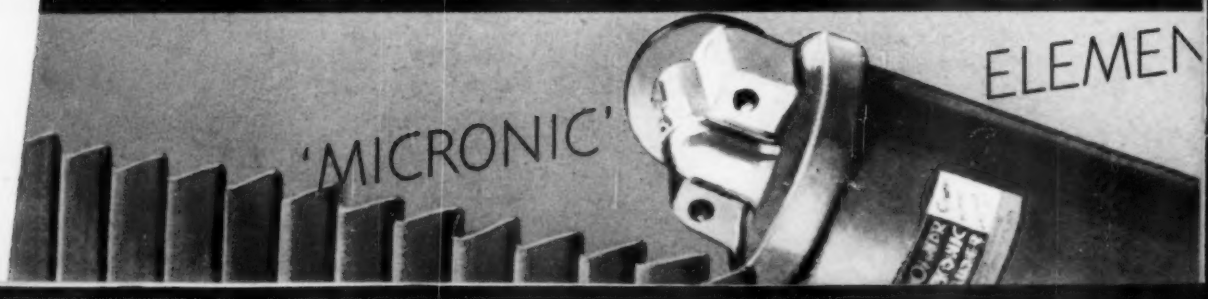


'MICRONIC' ELEMEN



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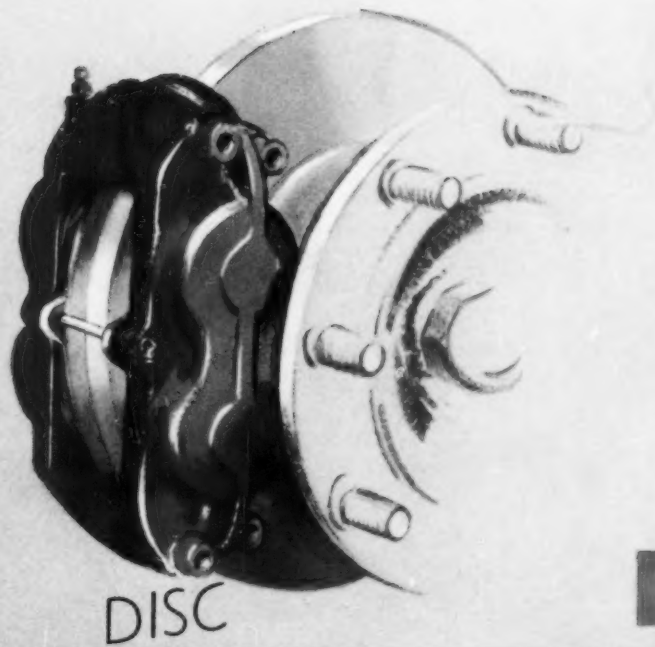

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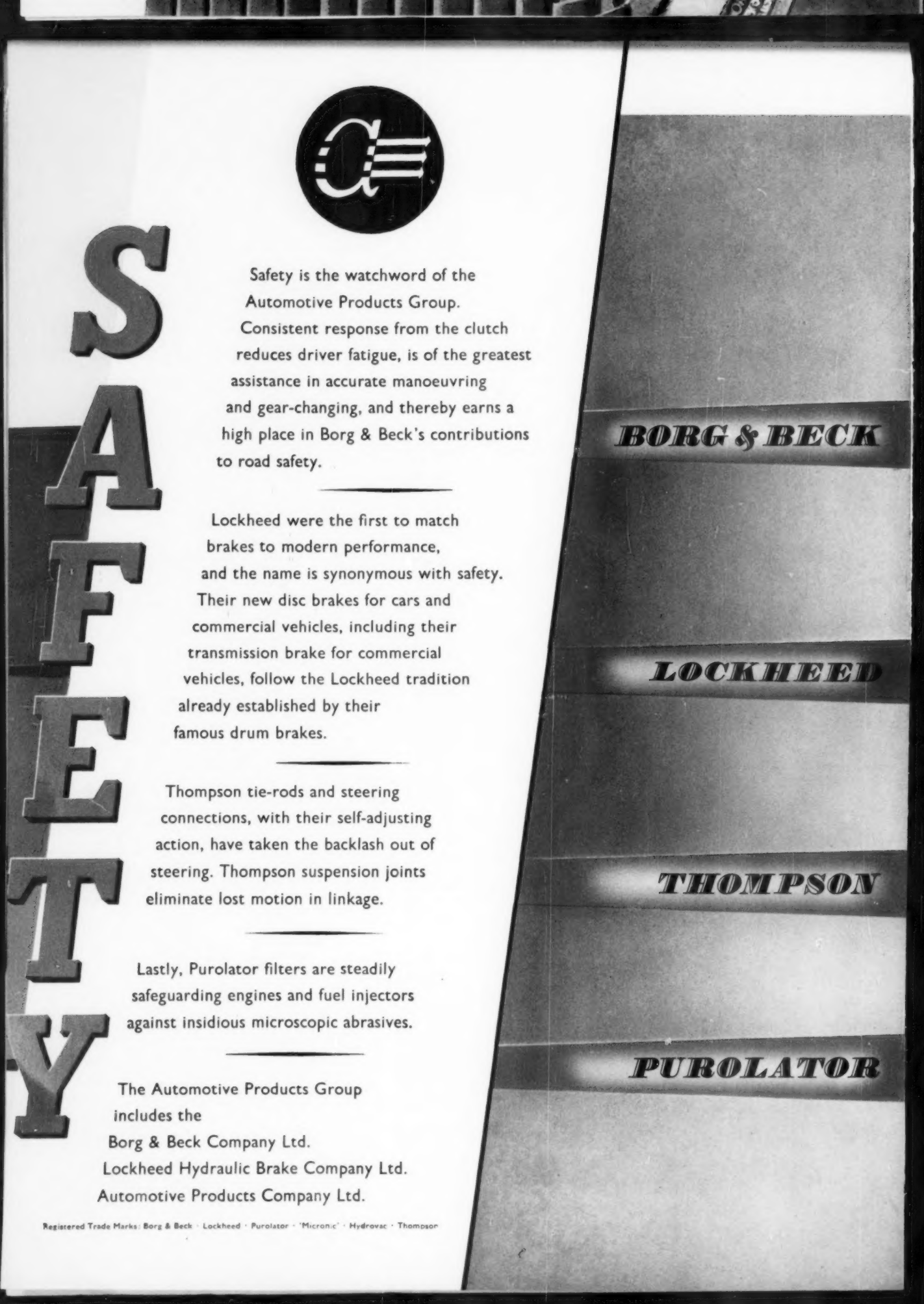
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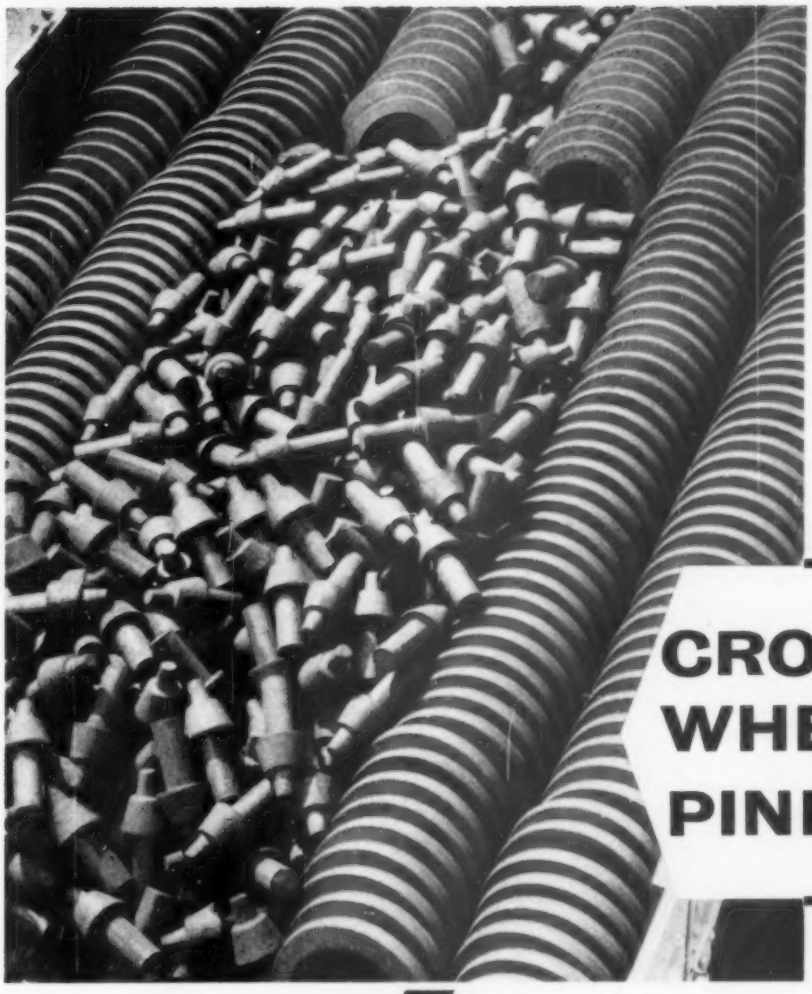

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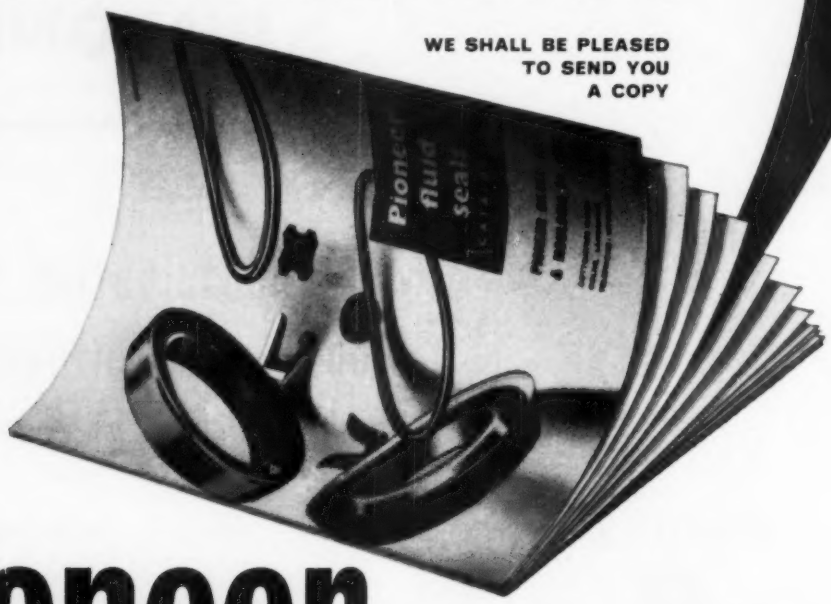

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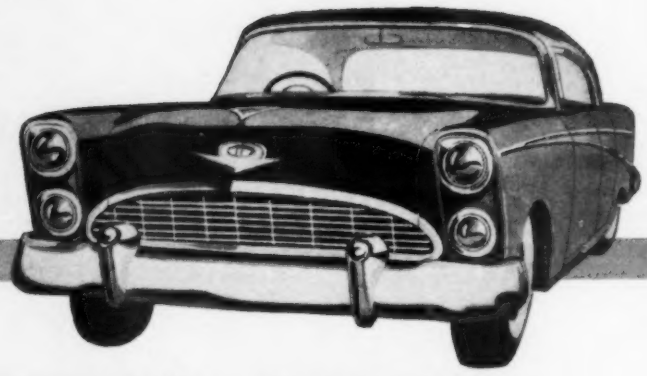

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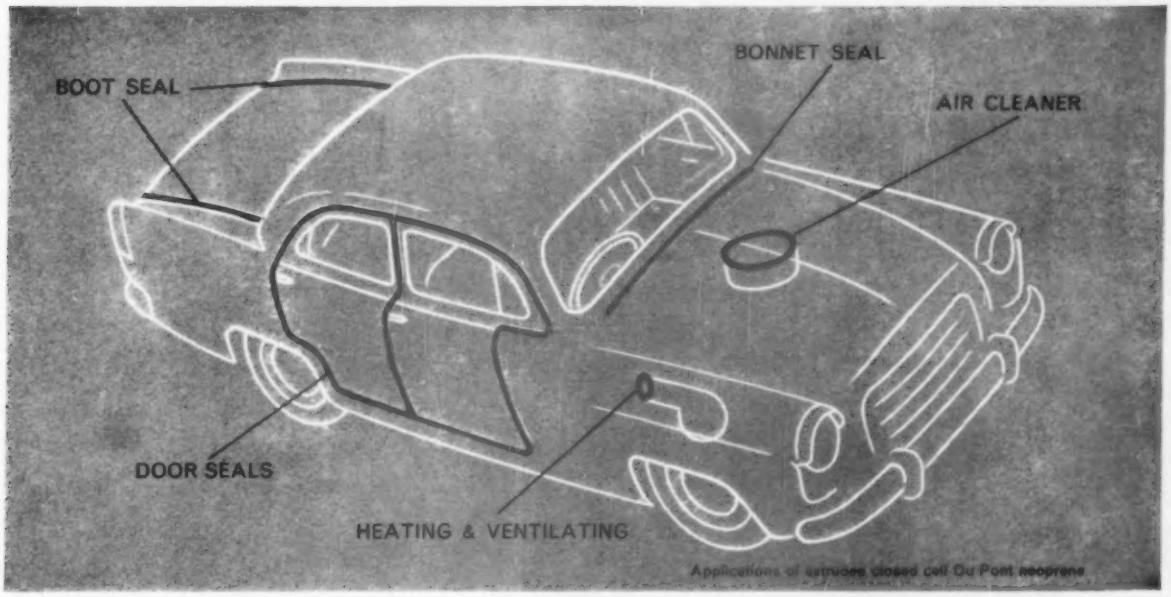
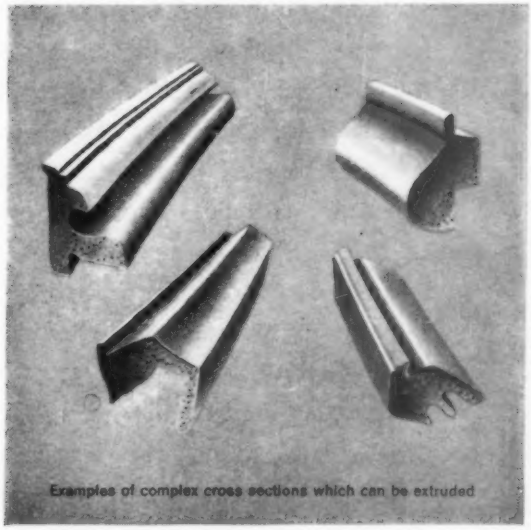


Applications of extruded closed cell Du Pont neoprene


Examples of complex cross sections which can be extruded

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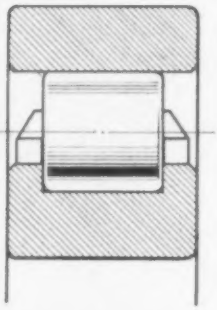

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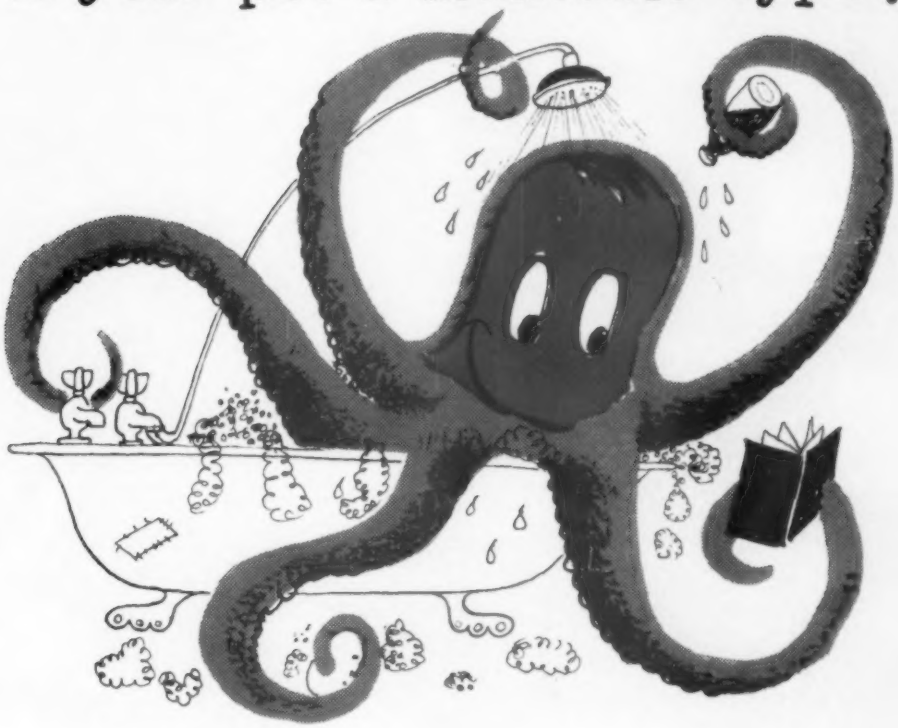

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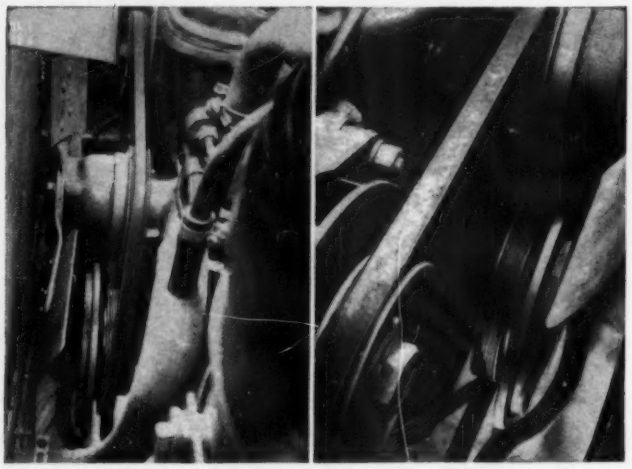

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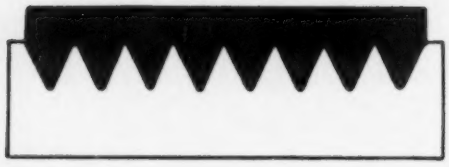

POLY-V* belt's multiple ribs grip pulleys throughout the entire friction surface—a surface twice the area of conventional multi-drives, one third more than conventional single drives.

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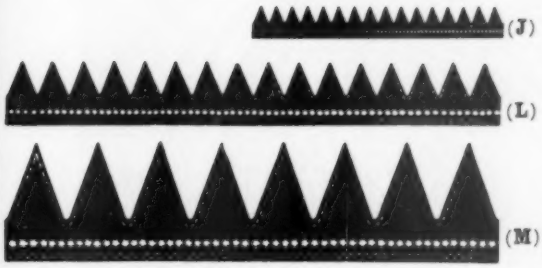

THERE ARE THREE BASIC RIB SIZES OF POLY-V BELT

Section	Rib Width	Rib Quantities	
		Minimum	Maximum
J	$\frac{3}{32}$ in.	2	16
L	$\frac{3}{16}$ in.	6	20
M	$\frac{3}{8}$ in.	4	20

V angle is 40° in each case.

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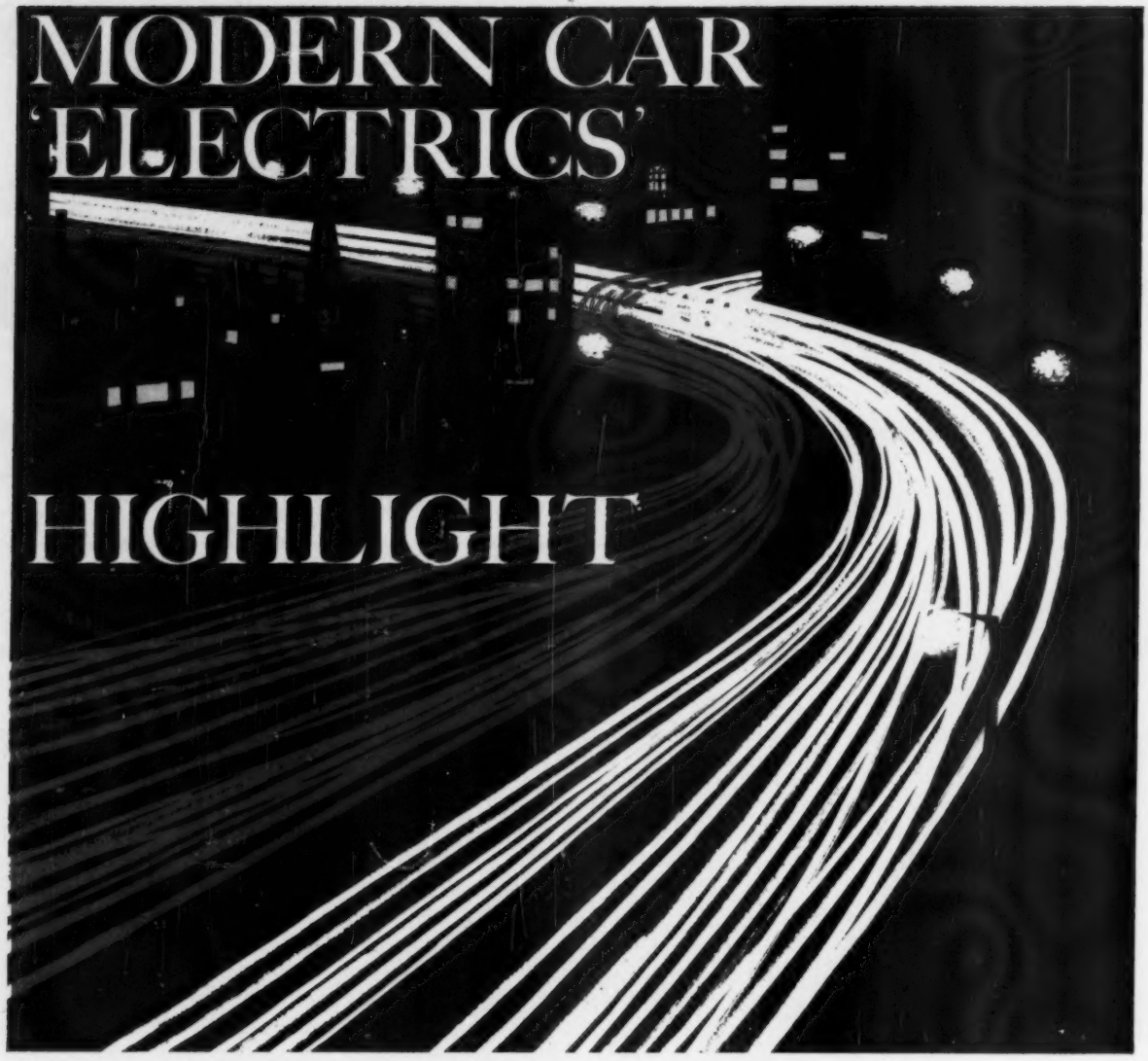
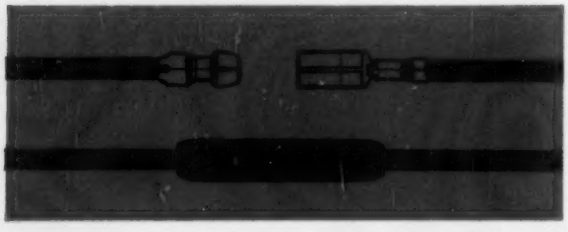


HIGHLIGHT

THE NEED FOR *A-MP



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A-MP Bullet Connectors and receptacles are designed especially for automotive uses. The Bullet consists of a ball ended connector which engages with a tumbler receptacle, both sections being covered by a flexible plastic insulating sleeve. The A-MP solderless system of crimped attachment is used, giving perfect conductivity and excellent mechanical support, so that wires neither break nor pull out, and inspection rejects are things of the past. The A-MP system is simple, effective, gives a high rate of production and therefore is economical in labour costs. Connections are vibration-proof, and can be made or broken at will without reduction of efficiency. Let us send you further details.

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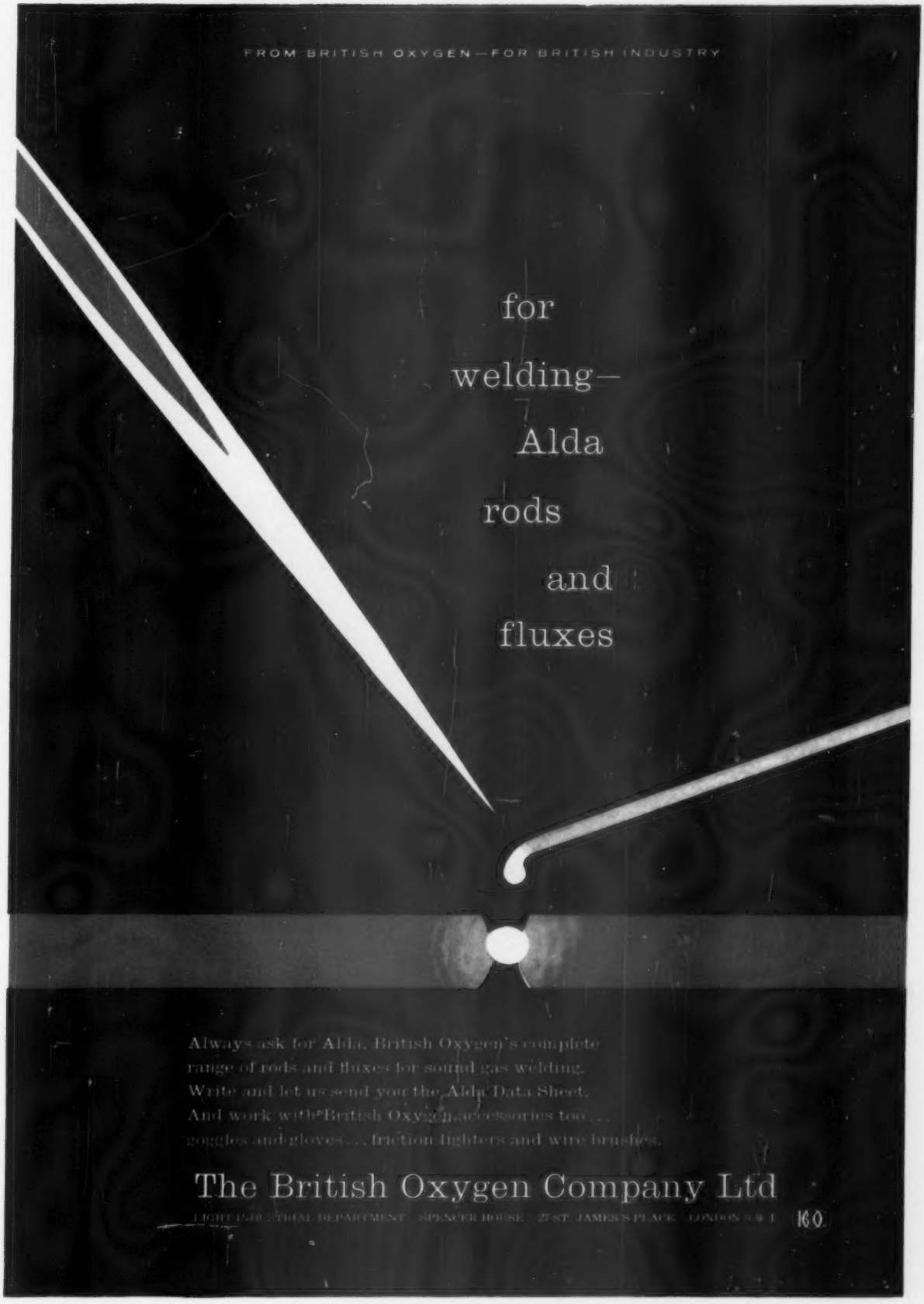
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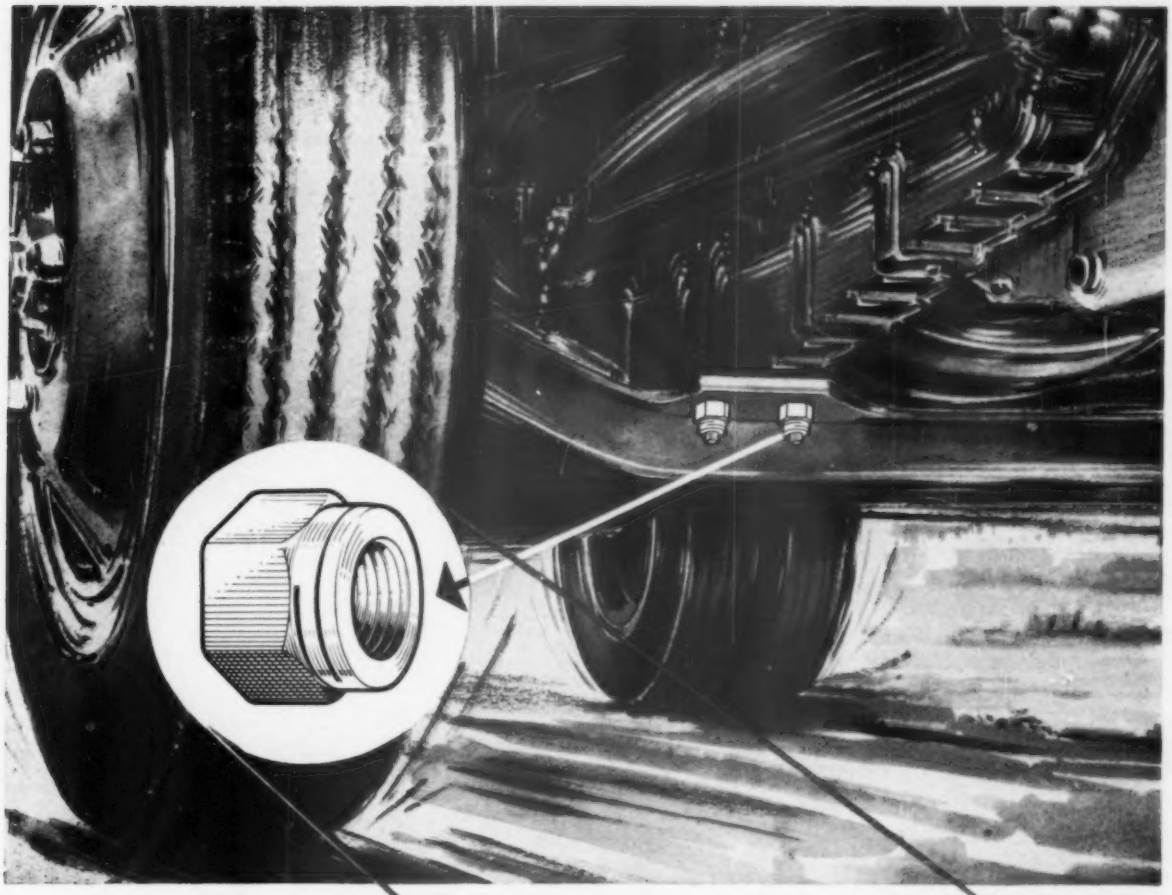

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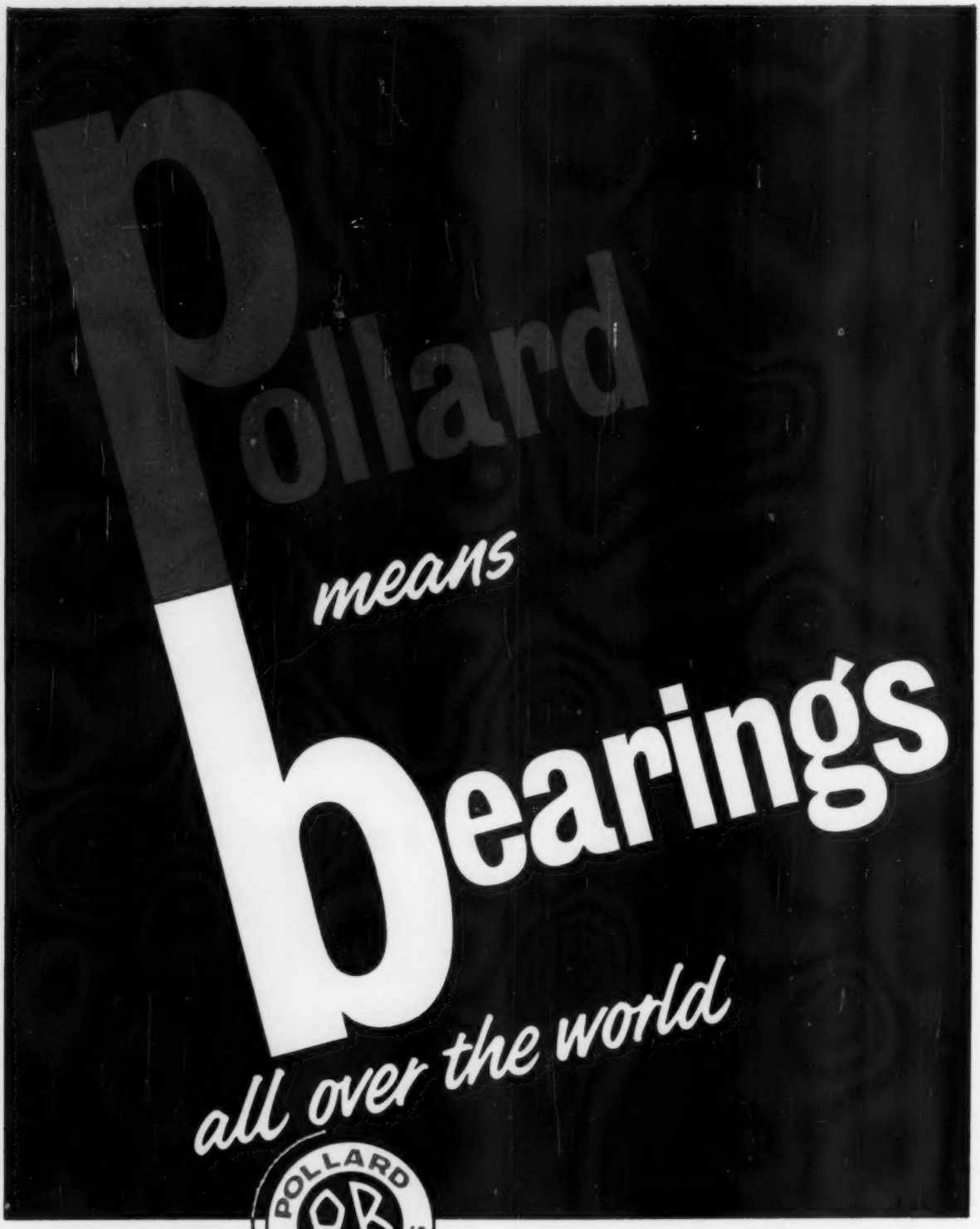

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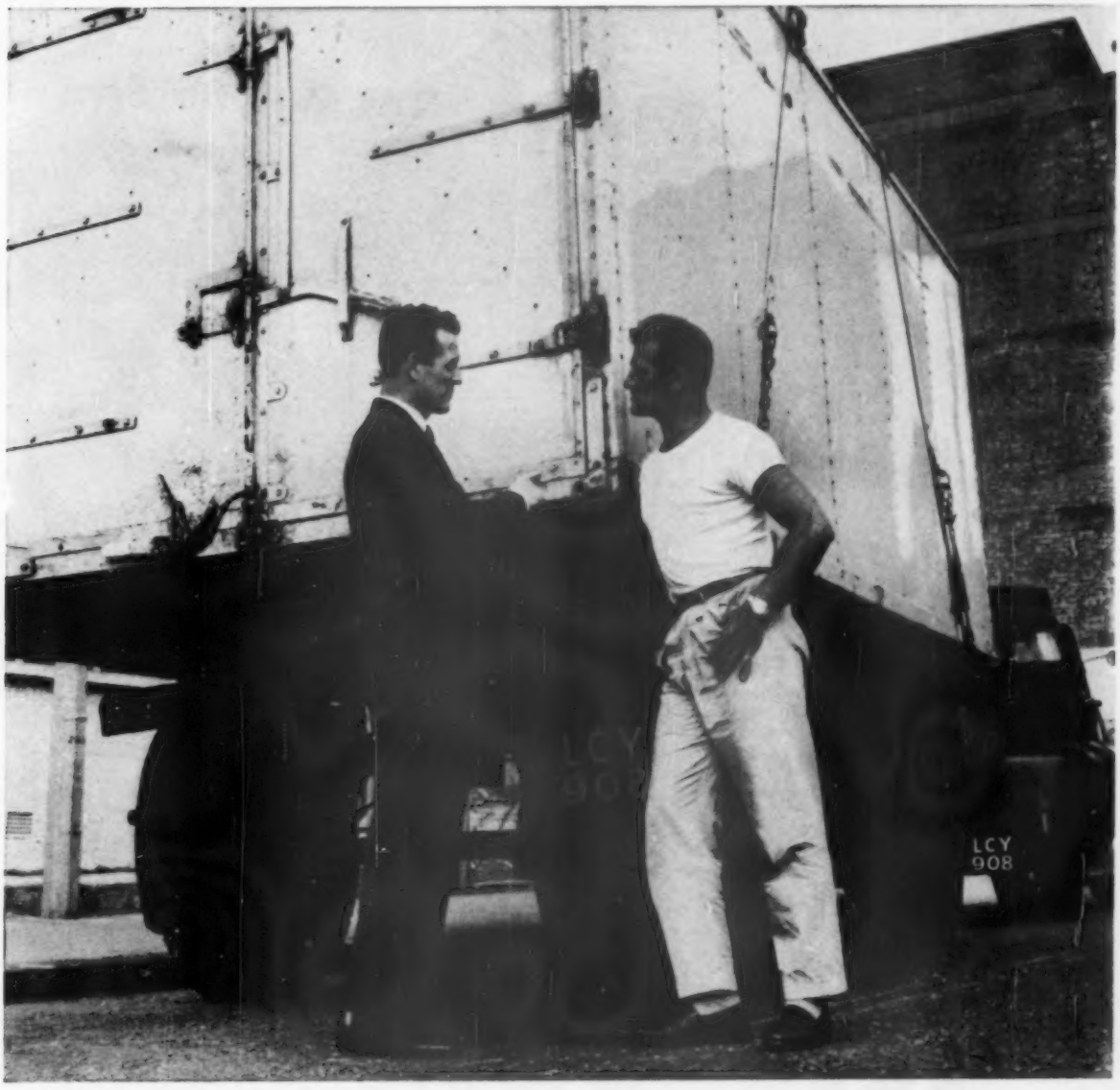

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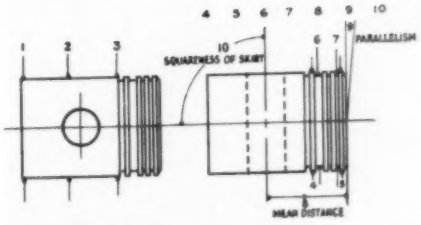

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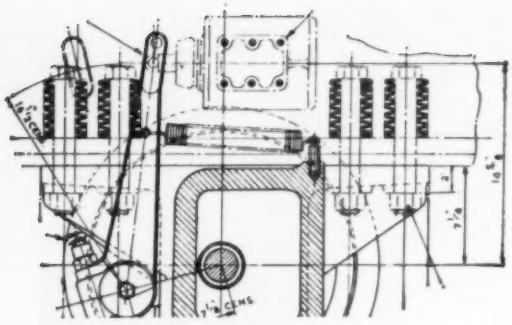
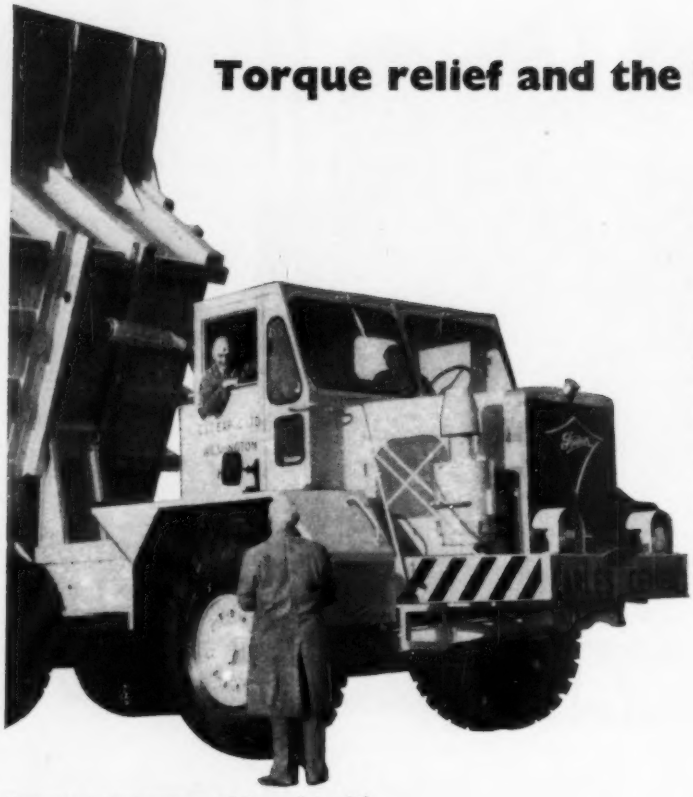


Torque relief and the Belleville Washer



Messrs. Fodens Ltd., fit Belleville washers in packs of 7 pairs on their F.R.6/45 Heavy Duty Dumper. This proved to be the most effective method of relieving twisting of the rear axle case produced by braking and transmission torques.

The potential uses of Belleville washers are endless.

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Salter technicians can help you. Their services are freely at your disposal.

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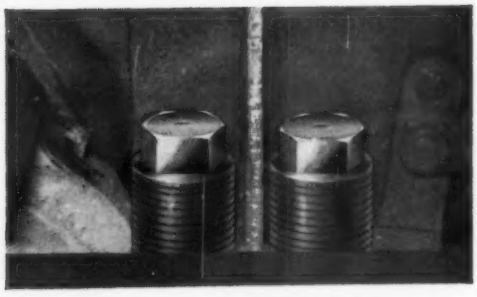

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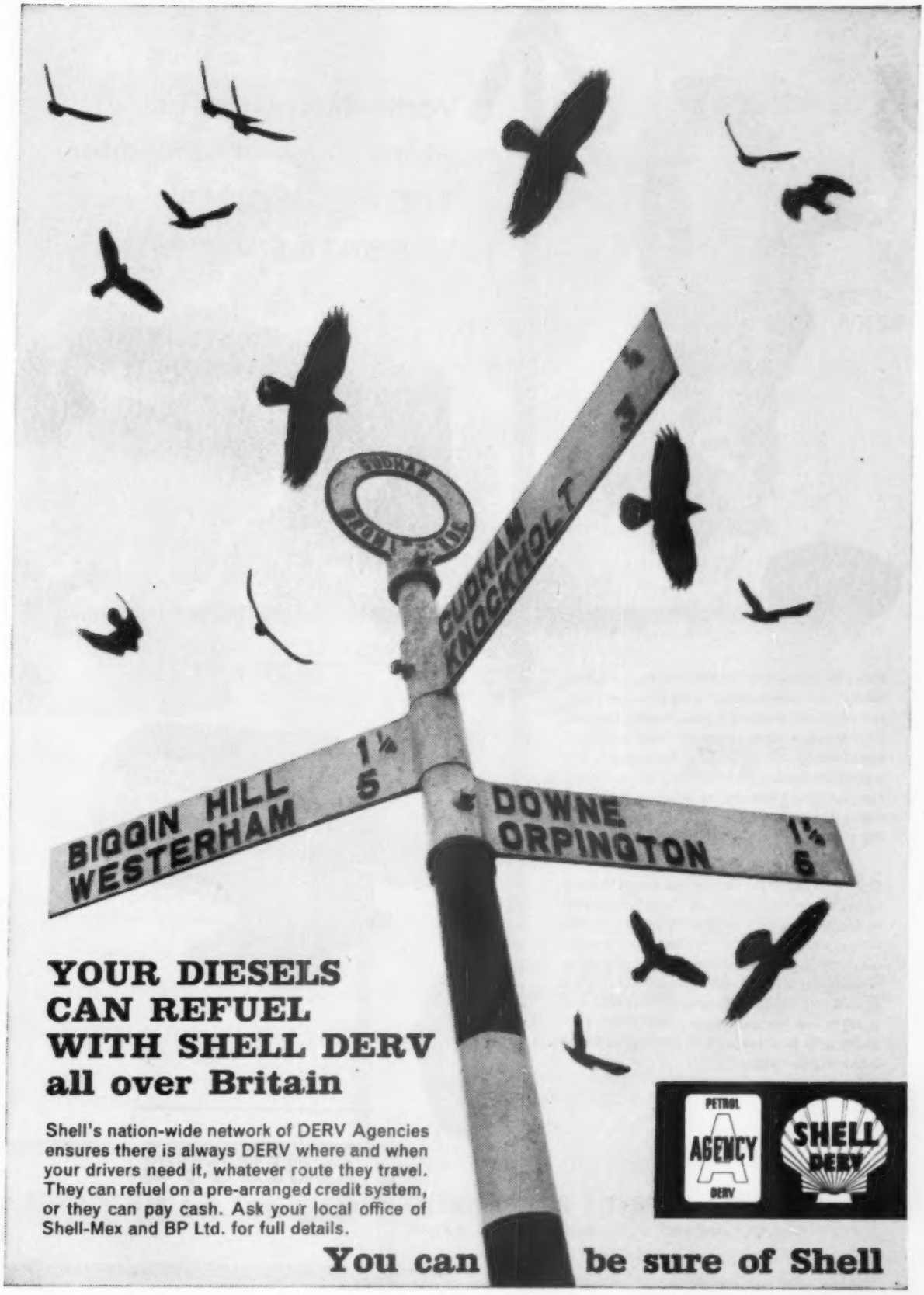
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THE INCREDIBLY VERSATILE VERSO

This new Holroyd 2¼″ centres worm gear speed reducer has been designed to meet the need for a self-contained motorised drive suitable for continuous use, and one which will look right in any surroundings. No matter what the application, it is possible to select from its variety of assemblies and mounting positions, an arrangement which makes it appear an integral part of the surrounding machinery, and *not* an added afterthought.

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REAR DRIVE AXLE

The Front Drive Steering Axle assembly is suitable for a 6 ton tyre load which makes it a perfect unit for 4-wheel drive systems where difficult and boggy terrain is encountered.

Illustrated above is one of our standard range of rear axles which is incorporated with the 4-wheel drive transmission.

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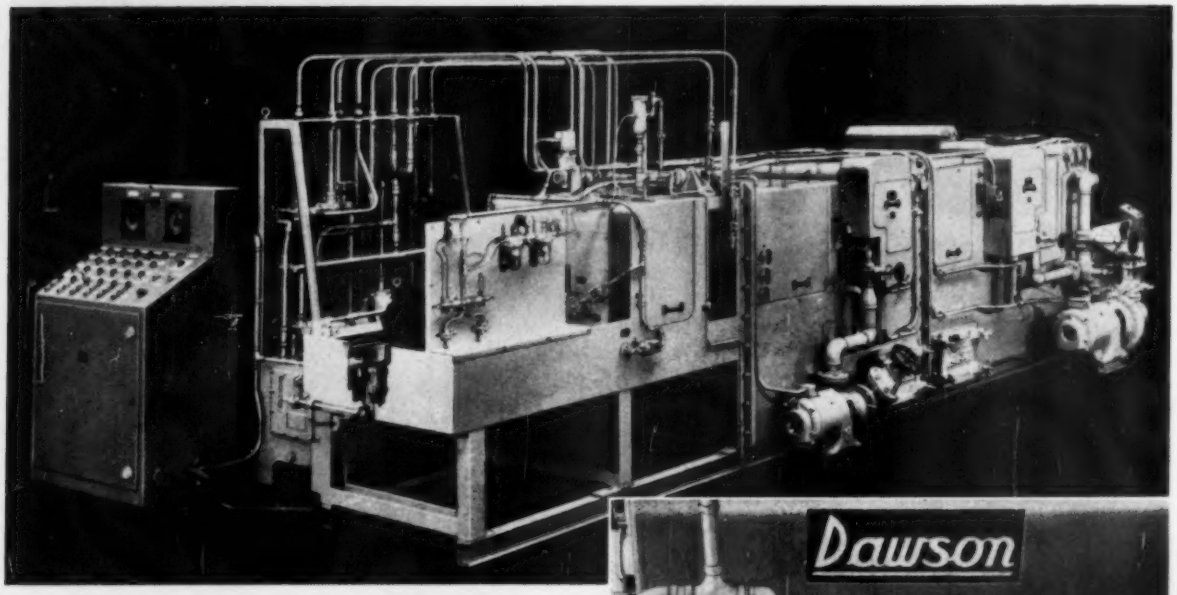
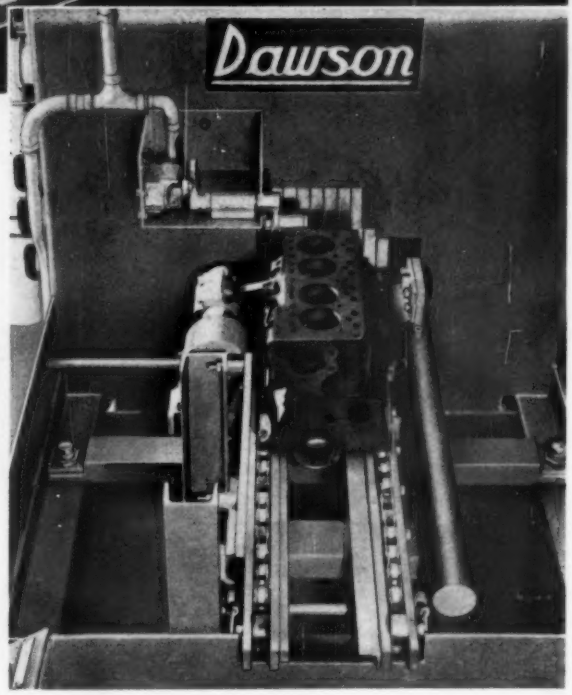
Fully Automatic "In Line" Cylinder Block Washing Machine





This fully automatic machine provides high precision cleaning to remove all cast iron swarf and cutting oils from cylinder blocks prior to the assembly of the engines. It will handle 80 blocks per hour.

The components are passed through the machine by means of a traverse bar. In this manner the cylinder blocks are carried through all the stages in an accurately controlled time cycle. At each treatment station the cylinder blocks are clamped accurately in position in relation to the jetting arrangements.

The eight stages of the machine consist of two flushing stations, a drain station a wash station with swing type jet boxes a further drain station and an air blasting station to the discharge station.

Dawson machines for cleaning and decreasing are available in a wide range of standard types and purpose designed plant has been supplied for many applications.

Write today for your copy of the Dawson catalogue describing the advantages of automatic cleaning.

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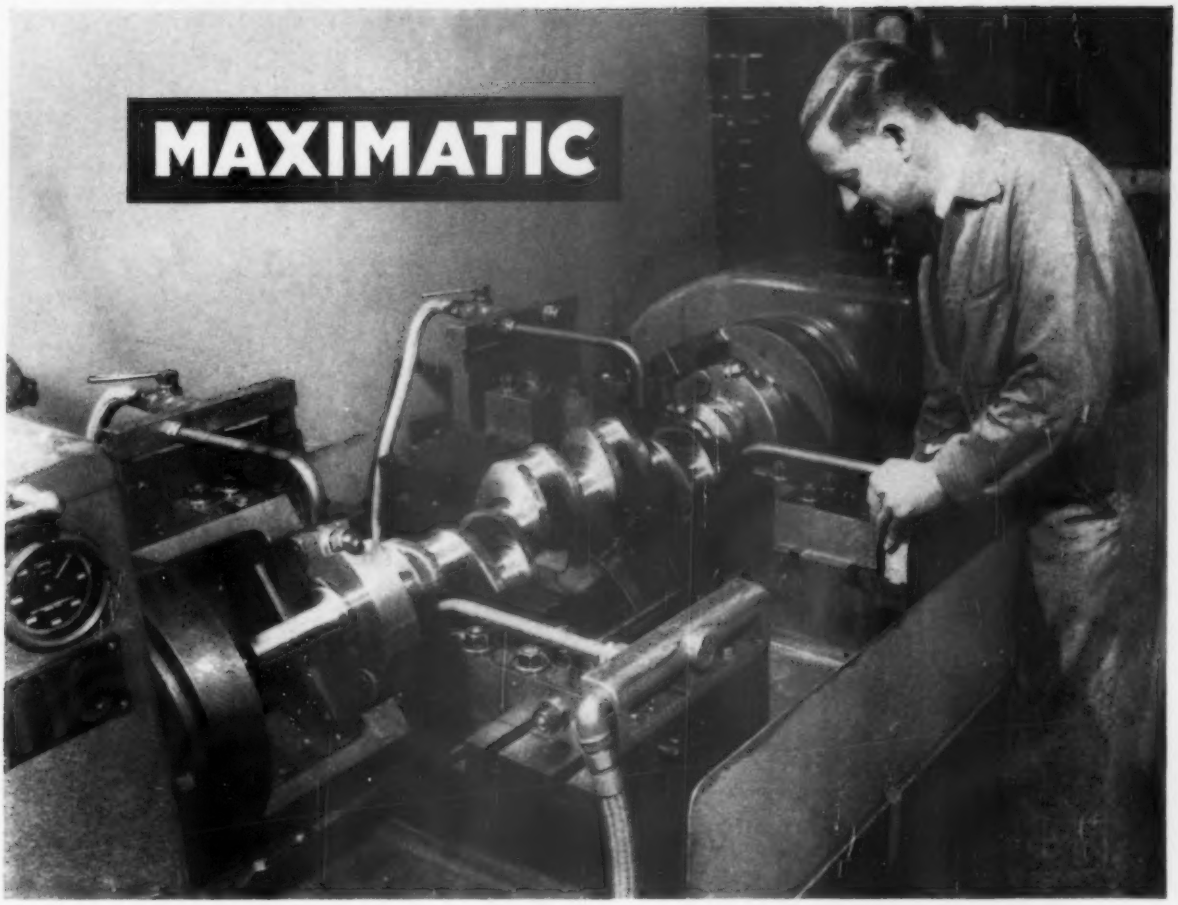
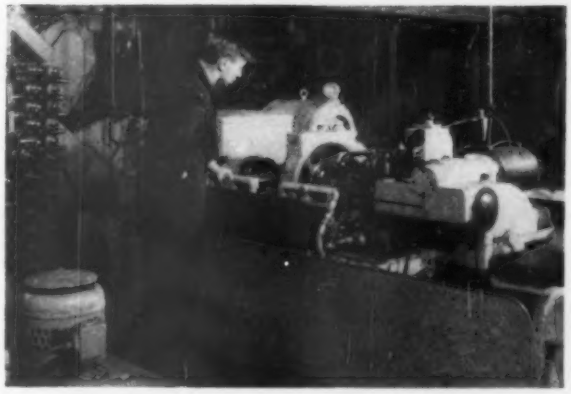


Multi-Tool Lathes for Crankshaft Turning

These automatic multi-tool lathes are widely used in the Motor Industry for turning operations on automobile crankshafts. The illustrations demonstrate the range covered by installations of "Maximatics". The photo above shows machining of A.E.C. Diesel engine cranks and in the lower view turning operations are in progress on Austin Seven crankshafts.

Drummond "Maximatic" lathes operate on a completely automatic cycle after starting the machine. High-output, accurate production is assured and they are equally applicable to the machining of many other components.



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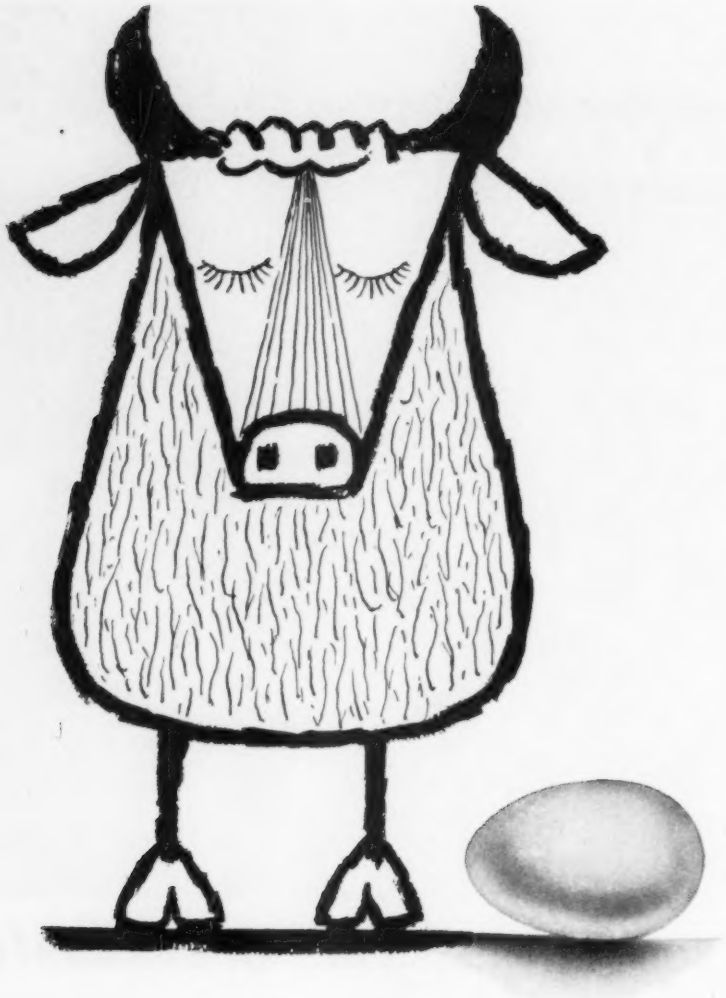

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TUFNOL is a laminated plastics material of such versatility that no engineer can afford to ignore it.

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RESISTS CORROSION
WITHSTANDS CLIMATIC EXTREMES
ELECTRICAL INSULATOR
MACHINES EASILY
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This component (weight 27·5 lb.) plays an important part in the torque converter of a machine of international repute.

As will be seen from the sectional drawing and the photograph, the sleeve embodies ducts for the hydraulic fluid, and is extensively machined. 'Lemax' heat-treated pearlitic malleables have versatile attributes, the ability to cast cored ducts of three-dimensional curvature, in combination with a material of great mechanical strength, adequate shock resistance and the requisite degree of hardness.

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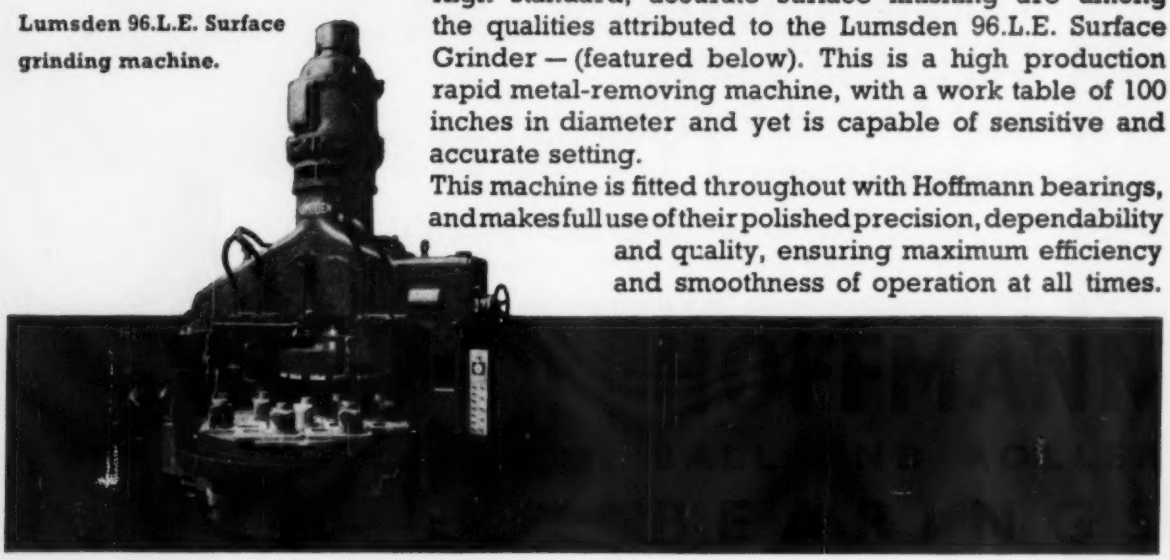

Lumsden 96.L.E. Surface grinding machine.

High standard, accurate surface finishing are among the qualities attributed to the Lumsden 96.L.E. Surface Grinder — (featured below). This is a high production rapid metal-removing machine, with a work table of 100 inches in diameter and yet is capable of sensitive and accurate setting.

This machine is fitted throughout with Hoffmann bearings, and makes full use of their polished precision, dependability and quality, ensuring maximum efficiency and smoothness of operation at all times.

Photograph by courtesy of the
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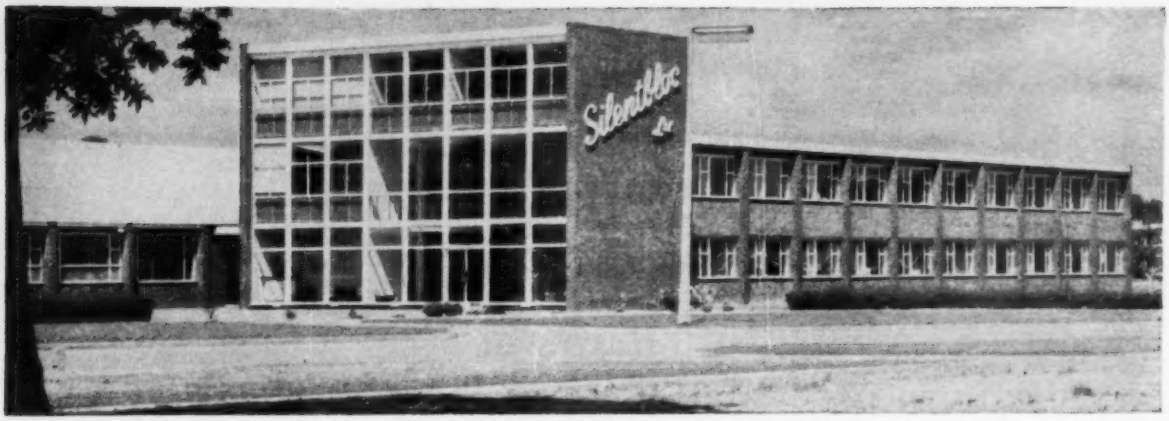
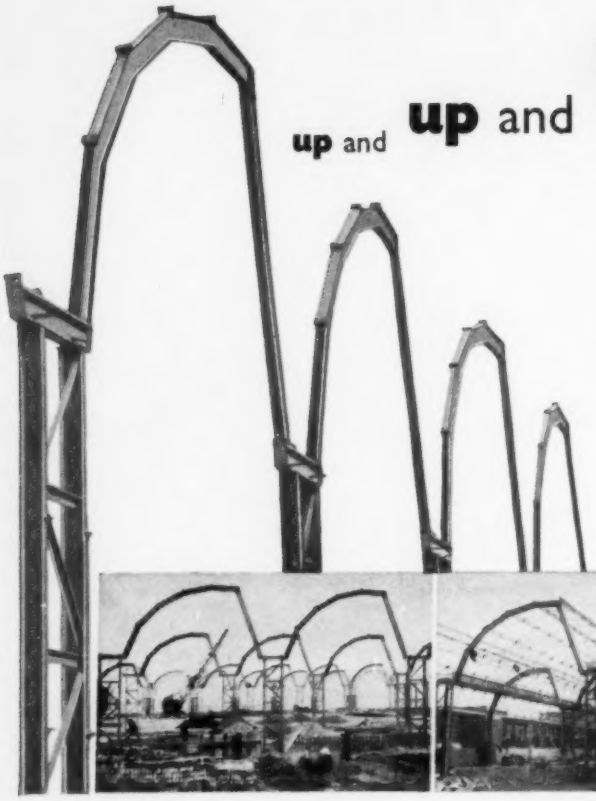


up and up and up



go the sales of Silentbloc products. And up and up and up goes the new extension which will almost double our factory area. This will not only give us increased productive capacity to meet growing demand, but will add significantly to our already excellent facilities for research and development. We mean to lead the industry in the future as decisively as we have led it in the past. The new extension will begin production early in 1961.

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The illustrations show the boring of a location pin hole in a fuel pump assembly fixture at the premises of Messrs. AC-Delco, Liverpool, by whose courtesy the photographs are reproduced.

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Prescollan components illustrated are Bellows, Diaphragm, Steering Joint Cover, Roller Section for rice mill, Buffer, Machine Tool Slideway Wipers and Silent Gears.

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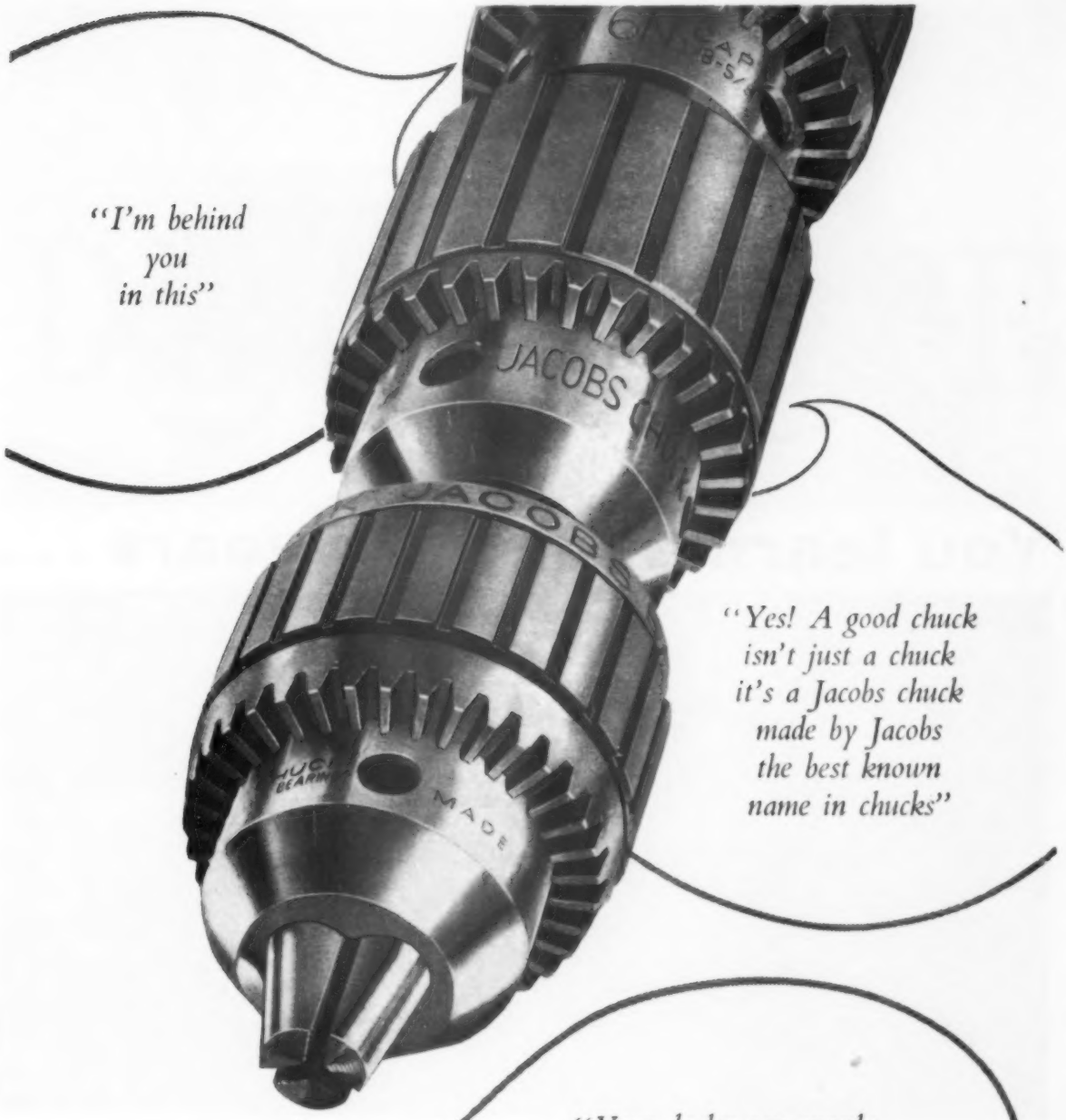

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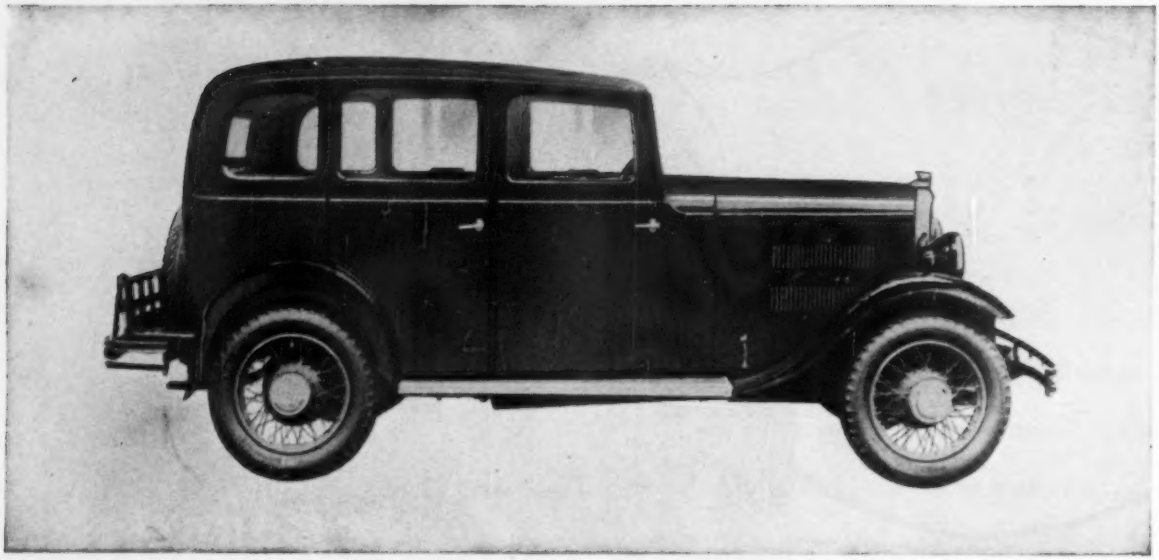

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for the Motor Industry

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industry
today . . .

DRAGONITE

electro-zinc coated steel
is
making things easier

(all kinds of things!)

Dragonite is taking the place of uncoated sheet steel in the manufacture of a constantly growing range of products . . . from domestic appliances to farm machinery, from radio and electrical equipment to lifts and office furniture. And there are good reasons why.

Dragonite is sheet steel which has been given a skin of zinc on both faces. It can be worked and welded just like uncoated steel but the surface of pure zinc gives greatly improved resistance to corrosion. Much longer periods of storage are possible before and after fabrication because the pure zinc coating is so ductile that it is not harmed by deep drawing and pressing. In fact, it acts as an excellent lubricant and saves on tool life.

Painting is easier, too, with Dragonite. The zinc surface forms an excellent base for paint. It reduces finishing costs and can increase the life of a painted surface up to five years over painted, uncoated steel.

For more detailed information about Dragonite and how it might fit in with your production plans, please write for a copy of the Dragonite Technical Handbook to:

THE STEEL COMPANY OF WALES LIMITED

Sales Offices: United Kingdom - Abbey Works, Port Talbot, Glamorgan. Overseas - Margam House, 26 St. James's Square, London, S.W.1

Behind the famous motoring faces lie....

FORD
DU bushes are used in the clutch pedal assemblies of the current Consul/Zephyr range.

ASTON MARTIN
DU pivot bushes for control pedals prevent "stick-slip". The timing chain tensioner sprocket and the gear box remote control incorporate DU.

JAGUAR
Fitted with DU pivot bearings in the clutch and brake pendant pedals.

STANDARD VANGUARD
Fitted with Borg Warner overdrive, incorporating DU bushes.

HUMBER SUPER SNIPE
DU thrust washers and bushes in the king pin assemblies have caused a marked reduction in steering effort. A DU bush is also used in the gear change linkage.

• Some examples of the extensive use of Glacier dry bearings in private vehicles.

GLACIER *DU BEARINGS

DU dry bearings and bushes are low in cost and are proving their worth on an increasing number of vehicles. Many leading companies in the Motor Industry use them in suspension, steering mechanisms, gear change linkages, brake-clutch controls, etc. They do not require lubrication, have a high load carrying capacity with low friction and "stick slip" is eliminated. Glacier DU accommodates abrasive particles and gives considerably reduced shaft wear.

*Glacier DU dry bearings and bushes are composed of a steel strip lined with a sintered porous bronze layer impregnated with a mixture of a fluoro-carbon plastic (P.T.F.E.) and lead.

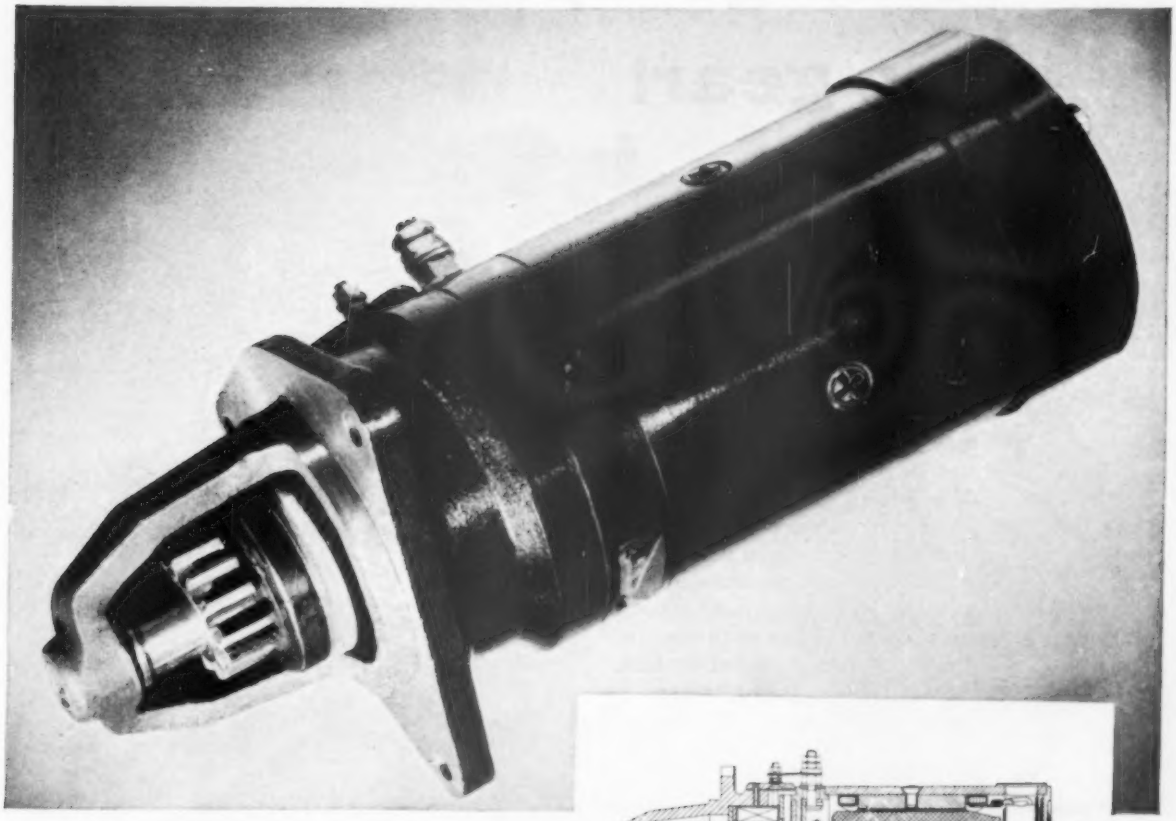
GLACIER

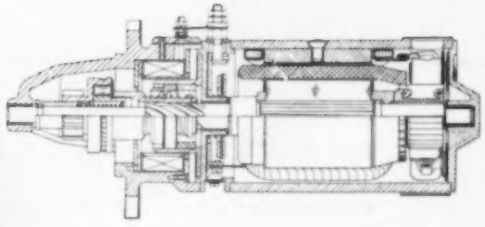
For details of the range and properties of Glacier dry bearings, write for a free copy of the Designer's Handbook No. 2 to:

THE GLACIER METAL COMPANY LTD · ALPERTON · WEMBLEY · MIDDLESEX

Simms

4½" CONCENTRIC STARTER





Does the work formerly done by a 5" starter. The cylindrical construction without projections makes for simple installation and easy withdrawal.

The pinion is positively engaged by magnetic action instead of by inertia.

It has a free-wheel pinion drive and built-in magnetic lock.

SIMMS MOTOR UNITS LIMITED · EAST FINCHLEY · LONDON · N2

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Drivers are doing it everyday—
manufacturers are doing it all the time!
The *top* gear today, of course,
being made by David Brown—just as it has
been for over fifty years. And
there's a good reason for this universal
approval of a famous name—for David Brown
make the biggest selection of gears
and gearboxes in the country. Every one is
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class for accuracy, quiet running and dogged
dependability.
David Brown make a full range of
auxiliary drives too—for timing, magneto,
oil pump, speedometer and starter,
and these are as widely used as their main
transmissions. It adds up to this—for
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more and more manufacturers are
going straight into top with David Brown.

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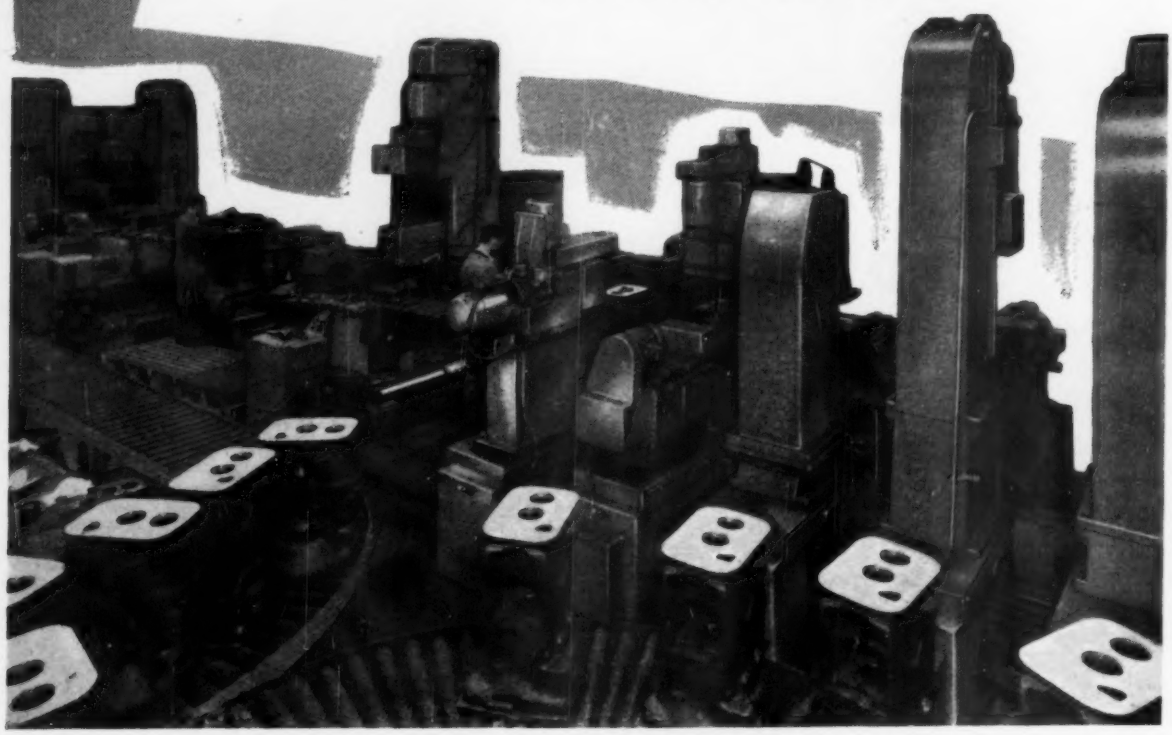
The Standard Motor Co. Ltd., Coventry, is only one of scores of factories where ARCHDALE special drilling and milling machines, as well as automatic transfer lines, are contributing to reduced costs, improved output and quality.

If you are producing components on a large scale, involving drilling, milling, tapping, boring or spot-facing, or any combination of these operations, ARCHDALE can certainly show you the way to lower costs.

We shall be pleased to submit complete schemes for your consideration. Get in touch with us.



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BLACKPOLE WORKS, WORCESTER. TELEPHONE: WORCESTER 27081 (6 LINES)

A Member of the Staveley Coal & Iron Co. Limited Group

Sole Agents: ALFRED HERBERT LTD., COVENTRY Telephone: Coventry 89221

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WEIGHT AND COSTS

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Our new range of Pressure Die Casting machines up to 1,200 tons can produce precision castings in quantity up to a maximum area of 265 sq. ins. with weights of 110 lb. in zinc or 44 lb. in aluminium alloy. The reduced machining costs and better weight ratios are readily appreciated by vehicle manufacturers . . . would they not interest you also?

West Yorkshire Foundries Ltd

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Phone: Leeds 29466

London Office:
HANOVER HOUSE, HANOVER SQ. W.1
Phone: MAYfair 8561

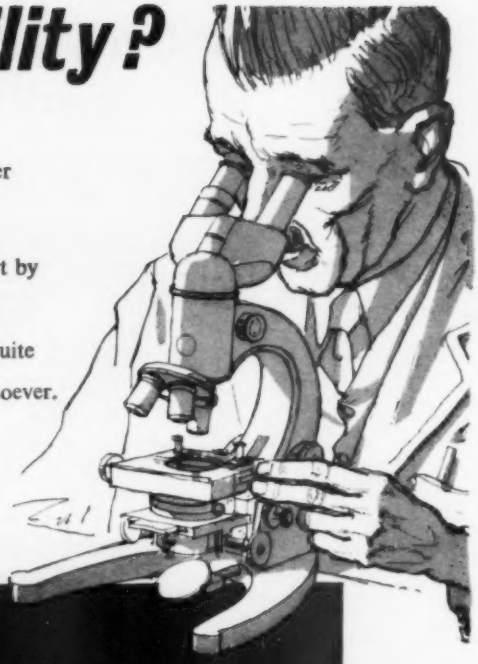
CAST WELL AND TRUE

What is filter *Stability?*

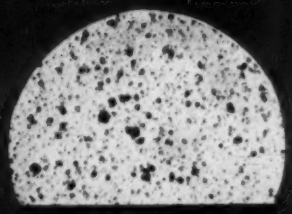
A filter should do its work with equal efficiency throughout its working life. It should be *stable*. The C.A.V. paper element fuel filter continues to work efficiently right up until it is finally choked.

Many filters on the market do not, however. On test, they may start by showing a fair efficiency, but later, more and more of the abrasive particles pass through the filter material. Such unstable filters are quite useless, and are no safeguard to your fuel injection equipment whatsoever.

These photomicrographs of fuel tell the story of actual tests.



STABLE

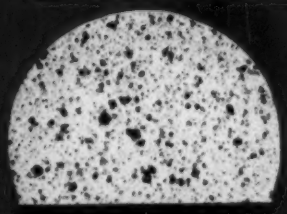


1 Fuel laden with abrasive dust, before filtration

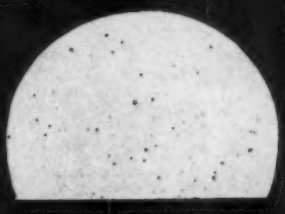
2 The same fuel after passing through a C.A.V. paper element filter at beginning of test

3 Fuel after filtration by the same element when all but choked by waxy sludge and dirt

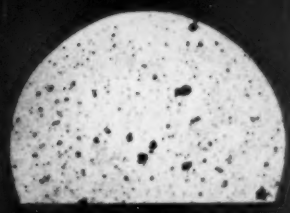
UNSTABLE



4 The same fuel is used for this test



5 At the beginning of test, filtration is fairly efficient



6 After the filter element is partly choked, the fuel passing through takes with it nearly all the particles of dust

There is only one genuine C.A.V. paper filter element. Substitutes are frequently unstable

TO BE SAFE, USE GENUINE C.A.V. REPLACEMENTS

C.A.V.

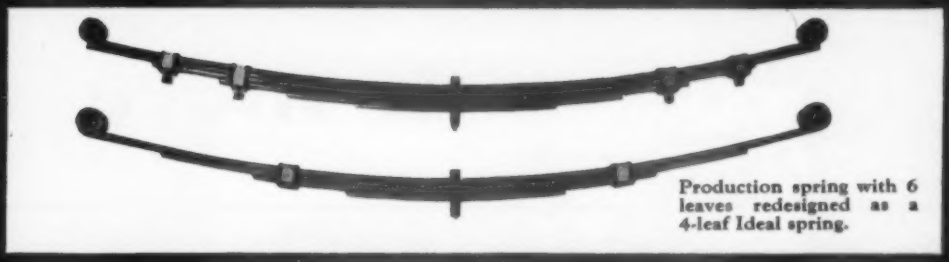
The World's Largest Manufacturers of

FUEL INJECTION EQUIPMENT

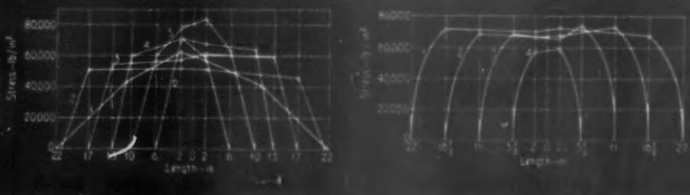
C.A.V. LIMITED · ACTON · LONDON · W.3

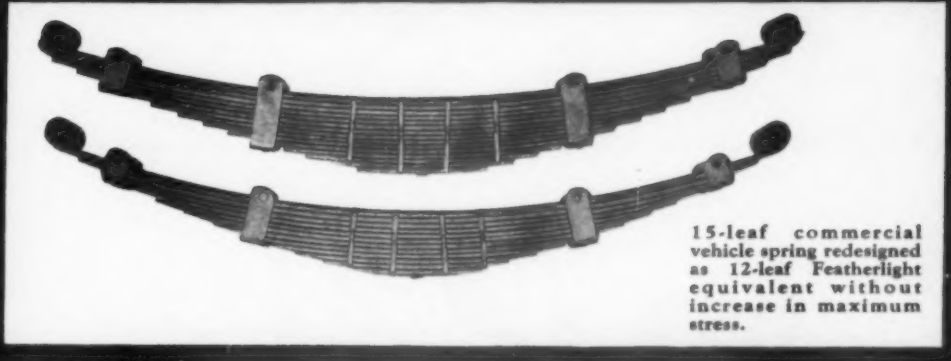
AP930

HOW TO SAVE SPRING WEIGHT WITHOUT INCREASING STRESS

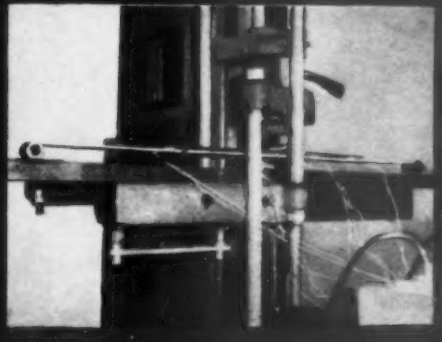


Production spring with 6 leaves redesigned as a 4-leaf Ideal spring.





15-leaf commercial vehicle spring redesigned as 12-leaf Featherlight equivalent without increase in maximum stress.



TWS
'featherlight'
IDEAL SPRING
PATENTS PENDING

TOLEDO WOODHEAD SPRINGS LIMITED
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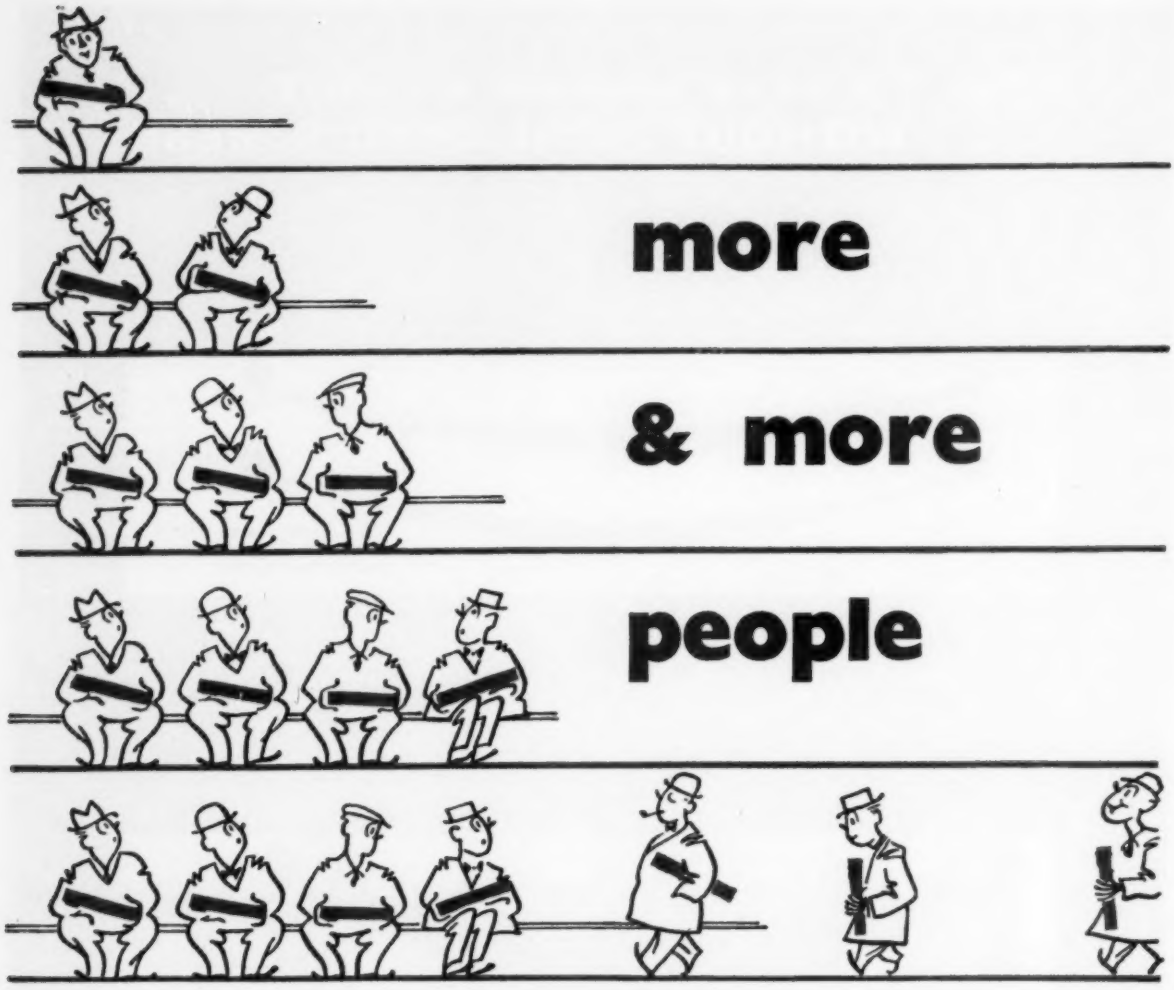
TWS 81



use Eclipse

'Eclipse' hacksaw blades and other tools are made by James Neill & Co. (Sheffield) Ltd. and are obtainable from all tool distributors.

UH 25

Heat treatment

Orchids grow best in the controlled heat of the greenhouse — and metal parts receive the best heat treatment in 'Cassel' salt baths.

With salt baths as with greenhouses, what counts is experience. The 'Cassel' Heat Treatment Service has long experience in carburising, heat treatment, tempering, martempering and austempering.

ICI

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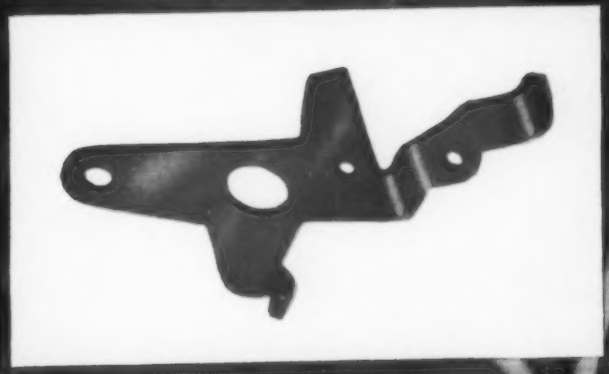
Imperial Chemical Industries Ltd.
London, S.W.1.

CC.[illegible]



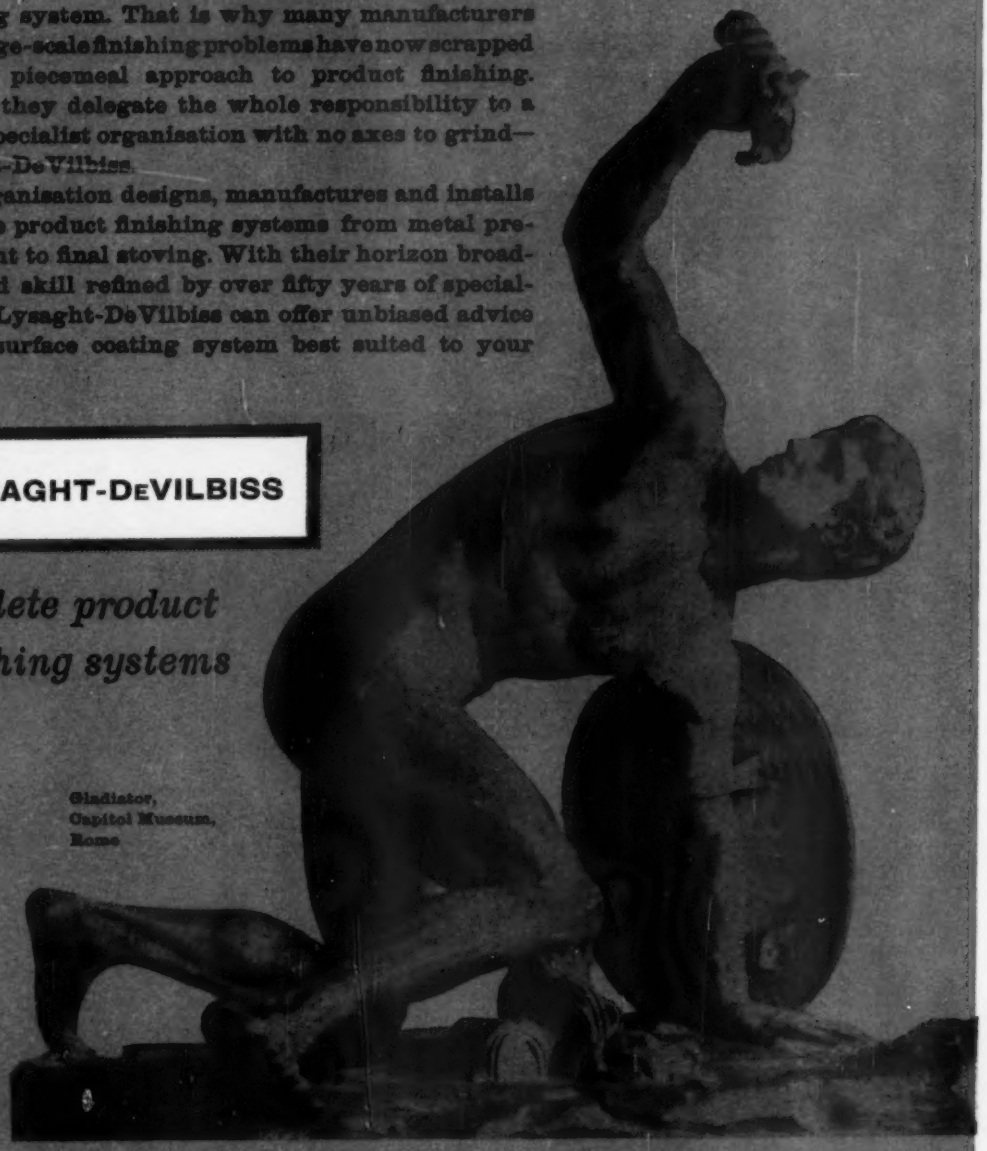
Where is the point ?

There is no point in taking on a dozen competing firms all pushing different pieces of finishing equipment. A mass of staff-consuming detail is involved tending to obscure the overall picture of a complete finishing system. That is why many manufacturers with large-scale finishing problems have now scrapped the old piecemeal approach to product finishing. Instead they delegate the whole responsibility to a single specialist organisation with no axes to grind—Lysaght-DeVilbiss.

This organisation designs, manufactures and installs complete product finishing systems from metal pre-treatment to final stoving. With their horizon broadened and skill refined by over fifty years of specialisation, Lysaght-DeVilbiss can offer unbiased advice on the surface coating system best suited to your product.

LYSAGHT-DEVILBISS

complete product finishing systems



Gladiator, Capitol Museum, Rome

LYSAGHT-DEVILBISS DIVISION OF JOHN LYSAGHT'S BRISTOL WORKS LTD.
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HIGH-SPEED STEEL
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HIGH-SPEED STEEL
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THE
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(INCORPORATING MANY NEW DESIGN FEATURES)

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The superior design of these products is the result of prolonged research and development. They are far in advance of similar tools of comparable price and much faster speeds and feeds are achieved with the cutters. Please write for leaflet No. 11 "AN ADVANCE IN MILLING".

★ *Comprehensive stocks constantly maintained*

SAMUEL OSBORN & CO., LIMITED
CLYDE STEEL WORKS · SHEFFIELD
Fine Steelmakers · Steelfounders · Engineers' Toolmakers

Brilliant Design

but
that's not all...

In the manufacture of propeller shafts and universal joints, Hardy Spicer are without equal. Through long association with every leading British vehicle manufacturer, Hardy Spicer have acquired that kind of technical 'know-how' which can only result from many years' experience. Skill and ingenuity are not enough. The vital ingredient of time is necessary before propeller shafts and universal joints can be mass-produced to give smooth, dependable transmission.

HARDY SPICER

PROPELLER SHAFTS

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AUTOMOTIVE DIVISION OF B

There's more than meets the eye

– in NPK Hexagon Socket Screws

There is far more to NPK Socket Screws than the fact that they are made from top-quality electrically melted alloy steel. GKN handle this high-grade raw material in a way that makes NPK Socket Screws conform to engineers' standards—the highest known to them.

GKN technique controls grain-flow and ensures precision and high performance. GKN Quality Control—from furnace to finish—makes it possible to guarantee that no NPK Socket Screw has a tensile strength of less than 75 tons/square inch. NPK Socket Screws are as good as they look.

NPK hexagon socket cap, set, countersunk and shoulder screws are available in a wide variety of sizes:

WEDGLOK self-locking hexagon socket screws and **NPK** hexagon wrenches are also available.

GKN

For price list and technical booklet write to:
GUEST KEEN & NETTLEFOLDS (MIDLANDS) LTD.,
Screw Division: Box 24, Heath Street, Birmingham 18. Telephone: Smethwick 1441. Telex 33-239

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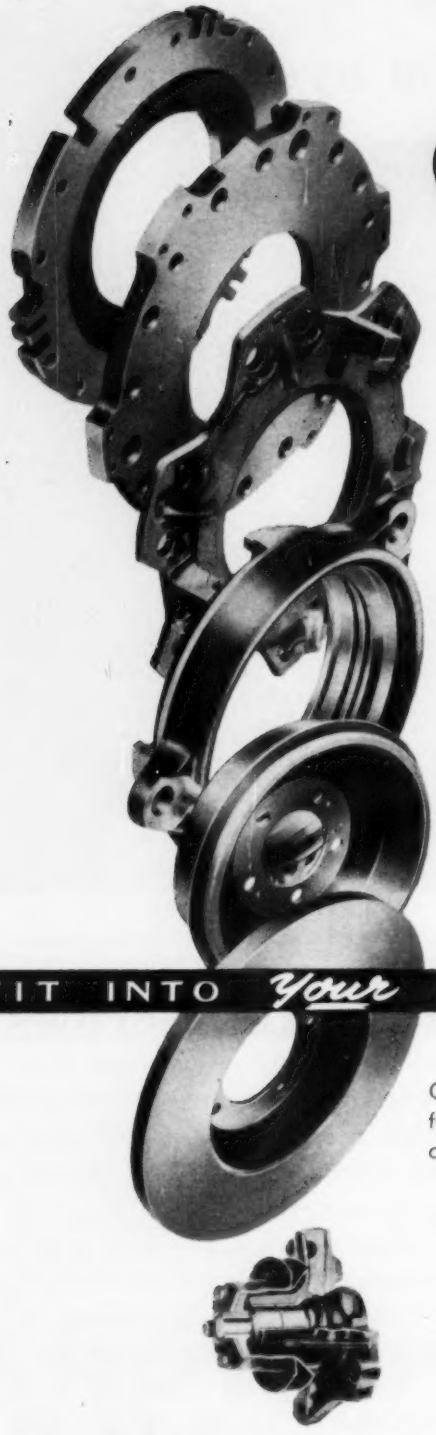

CONCENTRIC COMPONENTS

. . . occupy a very special place in the motor industry, many special places to be exact. Designed and precision engineered to ensure economy of operation and a long service life, they "fit" into most assemblies.

Oil Pumps, Water Pumps,
Steering Idlers,
Clutch Plates,
Gear Change Mechanisms,
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Brake Drums, Brake Discs,
Push Rods, Ball Pins,
Shackle Plates,
Axle and Hub Assemblies,
Thrust Plates and Assemblies,
Machined Components of all kinds.

FIT INTO *Your* SCHEME OF THINGS

Concentric specialists in the design and manufacture of Oil and Water Pumps, have achieved a new high standard of performance and production in this field.

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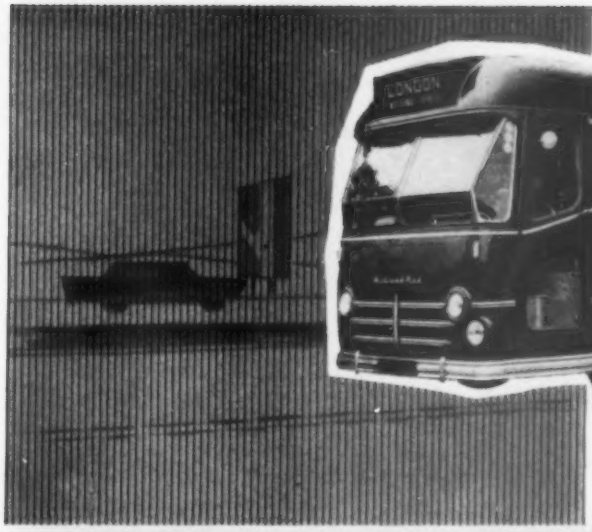
TELEPHONE : EAST 2081/2/3/4/5

On the Motorway



A completely new conception of public transport has been made possible by the London-Birmingham Motorway, with coaches cruising at speeds of 70-80 m.p.h. over its full length. These Midland Red Motorway Express Coaches, typifying this new era, are fitted with every modern device for safe, economical operation.

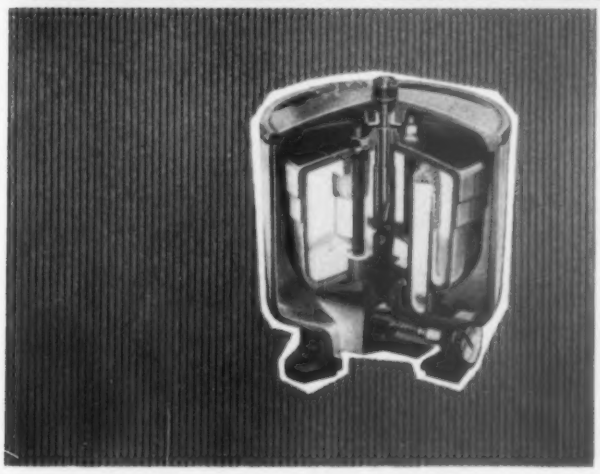
THE GLACIER

Glacier Centrifugal Oil Filters, for Transport and Commercial Vehicle Engines ensure optimum oil cleanliness at minimum operational cost.

centrifugal **OIL FILTER**

Fitted, among others, by the following leading engine manufacturers:-

LEYLAND MOTORS. DAIMLER - BENZ. ALBION MOTORS. CROSSLEY BROS. FIAT. BIRMINGHAM & MIDLAND MOTOR OMNIBUS CO. ISOTTA-FRASCHINI. E.N.A.S.A. (PEGASO) SPAIN. DAIMLER. SCANIA-VABIS.



Compared with conventional filters, Glacier extractors have a number of advantages:-

- They remove—consistently—particles down to under a micron.
- They have up to 10 times the dirt capacity of conventional filters, do not choke, and oil does not pass through contaminated sludge during filtration.
- They hold the percentage of contaminant of oil down to a level as low as 0.2% by weight.
- They enable the period between oil changes to be lengthened by up to 4 times.
- There is no element to be replaced at each cleaning.

GLACIER

FREE!
Send for Designer's Handbook No. 3 on Filters.
All correspondence on Filters to be addressed to:-
The Glacier Metal Co. Ltd., Kilmarnock, Ayrshire, Scotland.

THE GLACIER METAL COMPANY LTD · Alperton · Wembley · Middlesex.

Prestige are keen on Coal

OVER THE PAST twenty-one years one name has come to predominate in the homes—and particularly the kitchens—of housewives who appreciate well-designed, efficient domestic utensils. That name is Prestige. Such is the tremendous popularity of Prestige housewares today that three huge factories at Burnley, Derby and Blackburn are now in full production to meet the ever-growing demand for the Prestige range.

The men who control the policy of this great company choose *coal* to provide the steam power for their production processes. They know that coal, fired automatically and burned smokelessly, gives maximum efficiency at the most economical cost; that supplies of this home-produced fuel are assured for generations to come.

If your voice is a deciding one in the question of fuel for power, remember Prestige. Their judgment has proved that coal has the edge on all other fuels. You can prove it again—to *your* own profit.

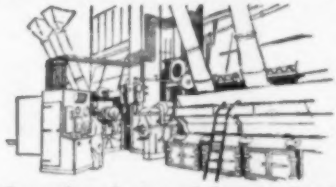
Coal Supplies the Power at Prestige's three factories at Burnley, Derby and Blackburn

Mr. Eric Horner, Group Maintenance Engineer, comments:—

"A regular watch has been kept on the cost of fuels other than coal, affecting the price of steam raised. But after studying costs over several years it is felt that only some absolutely unpredictable changes in fuel costs could unseat coal from its position as the most economical fuel for our use.

When the Company first operated in this country in 1937, coal was the obvious fuel chosen for one steam raising plant. But in 1946 and '47, as a result of the national fuel crisis, serious consideration was given to alternative fuels. Although detailed calculations showed that upwards of 70% efficiency can be readily obtained on coal firing, it was necessary to fit alternative means of firing on one boiler due to the temporary shortage of coal. It was therefore possible to make exhaustive trials—and the results confirmed calculations that coal is the most economical fuel. Later, as coal became available to meet our full requirements, *we reverted again to using only coal for steam raising.*

In 1956, to meet increased steam demand at the Burnley Plant, a third and larger coal fired boiler was installed. Because of the pending "Smoke Control Regulation" this installation was designed so that grit arrestors could readily be fitted if required. However, this has not been necessary, as the periodic reports from the Public Health Department have always given us a clean report."



Some key facts and figures about the consumption of coal in the Prestige boilerhouses:

Boilers:	7, including four economics
Method of firing:	Mainly Coking stokers
Steam pressure:	Up to 120 p.s.i.
Steam temperature:	340°F.
Continuous max. rating:	53,600 lbs of steam per hour
Annual fuel consumption:	5,220 tons of coal

PROGRESSIVE INDUSTRY IS GOING FORWARD ON

COAL

ISSUED BY THE NATIONAL COAL BOARD

the Rocol technical information service

Brochures dealing with

SPECIALISED LUBRICANTS

for industry

Engineering and other industrial firms are offered the following, as one aspect of ROCOL *service.*

Publication No. 1. **ANTI-SCUFFING PASTE AND OIL**

Anti-Scuffing Paste is the most effective means of applying Molybdenum Disulphide for dry lubrication. Used where ordinary oils and greases cannot be applied. Withstands immense heat and pressure, and has remarkable anti-seize properties. Approved under D.T.D. 900/4284. Anti-Scuffing Oil enables Molybdenum Disulphide to be used in circulating systems and oil lubricators.

Publication No. 2. **R.T.D. COMPOUND**

The modern lubricant for severe metal forming and shaping operations. Counters the effects of high pressure and eliminates frictional heat in drilling, reaming and tapping stainless steel, alloy steels, nickel and titanium. Can lengthen tool life by as much as 30 times.

Publication No. 3. **MOLYBDENISED LUBRICANTS**

The remarkable low friction and pressure resisting properties of Molybdenum Disulphide have been incorporated in a wide range of specialised lubricants, compounds and varnishes described in this Brochure.

Publication No. 4. **WATCH AND CLOCK OILS**

A complete range for the Horological and Instrument Engineer, based on joint research of horologists and oil technicians. Includes a range of synthetic oils which remain fluid down to minus 65°C; and Molybdenised Oils in all viscosities.

Publication No. 5. **KILOPOISE LUBRICANTS**

Extreme-viscosity lubricants to damp motion and ensure a slow, even action in hand operated components such as optical focusing movements, variable condensers and potentiometer spindles. Widely used throughout the optical, instrument, radio and electrical industries. Special grades available for use as Core Locking Compounds.

Publication No. 8. **MOLYTONE GREASE**

A series of greases combining Rocol Bentone Grease and Molybdenum Disulphide. They have no melting point and are effective from below zero to 450°F. They withstand extreme pressures and provide positive lubrication even in 'starved' conditions. They should be used in all grease systems where extra boundary lubrication is demanded by severe working conditions.

Write to ROCOL *about lubrication.*

ROCOL LIMITED,
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(Telephone : HOLborn 1985).

ROCOL HOUSE, SWILLINGTON, Nr. LEEDS.
(Telephone : Garforth 2261).

no lunch today...

'THE IRON MAN'

or any day

IT WORKS THE CLOCK ROUND

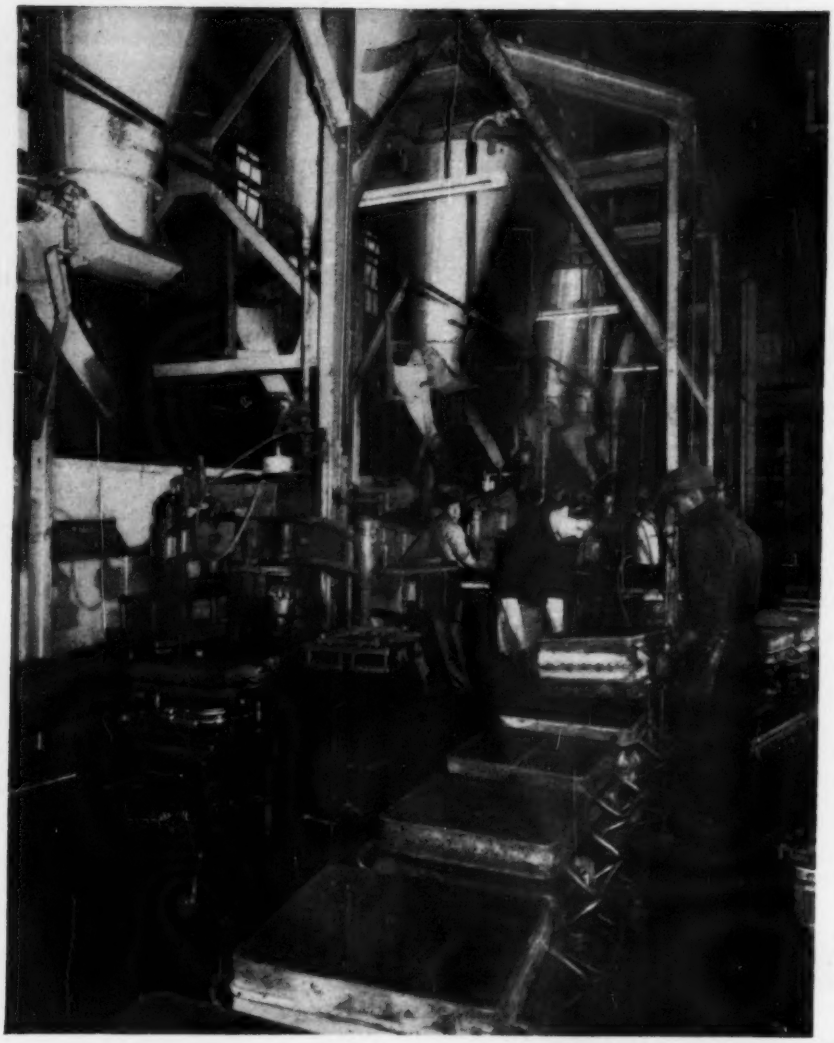
Sciaky 'Iron Man' needs no lunch . . . works 24 hours a day—another example of Sciaky ingenuity. The 'Iron Man' device was the low cost answer to motor manufacturers problem of fabricating pressure-tight vacuum and petrol tanks at high speed using unskilled labour.

All that is required of the operator is to load the half pressings and remove the completed component. This successful application is the direct result of the adaption of resistance welding to the application—the Sciaky technique—get on to Sciaky ingenuity, it can work for you too!

SCIAKY

SCIAKY ELECTRIC WELDING MACHINES LIMITED · FALMOUTH ROAD · SLOUGH · BUCKS

Telephone: SLOUGH 25551 (10 lines)



CBS

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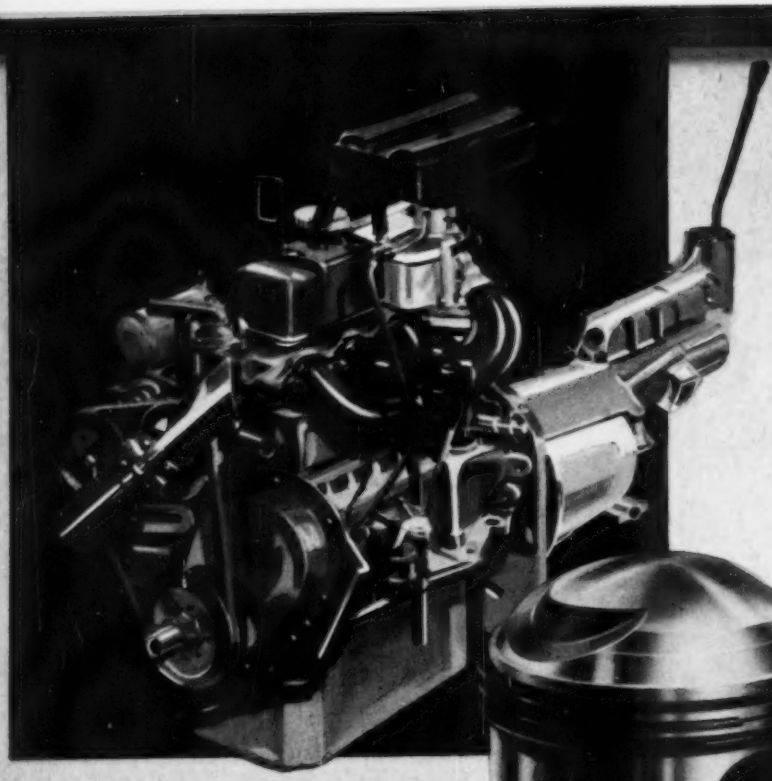

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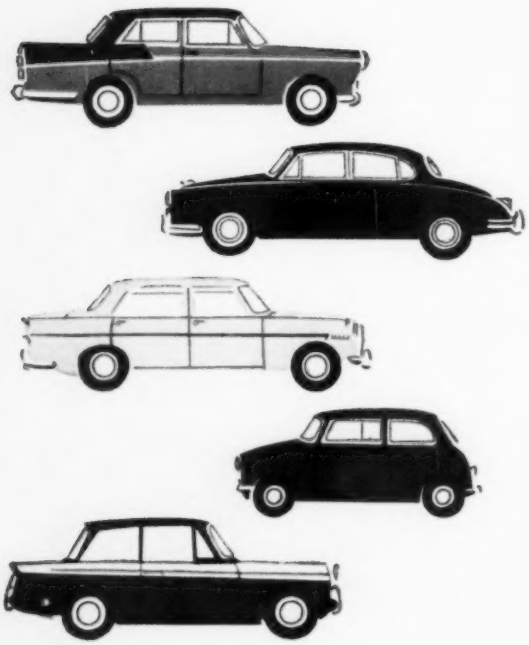

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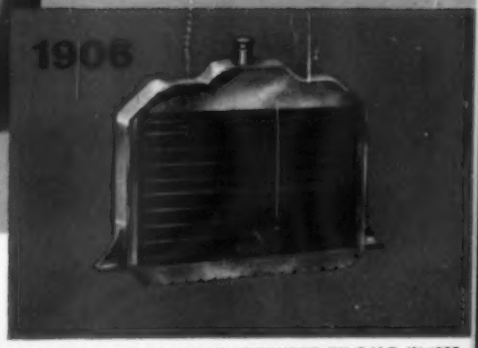

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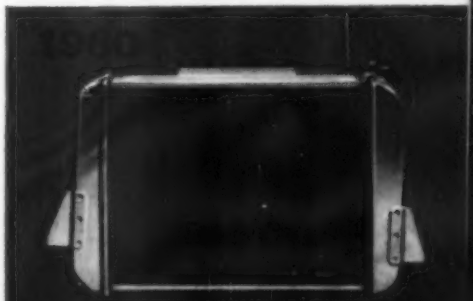

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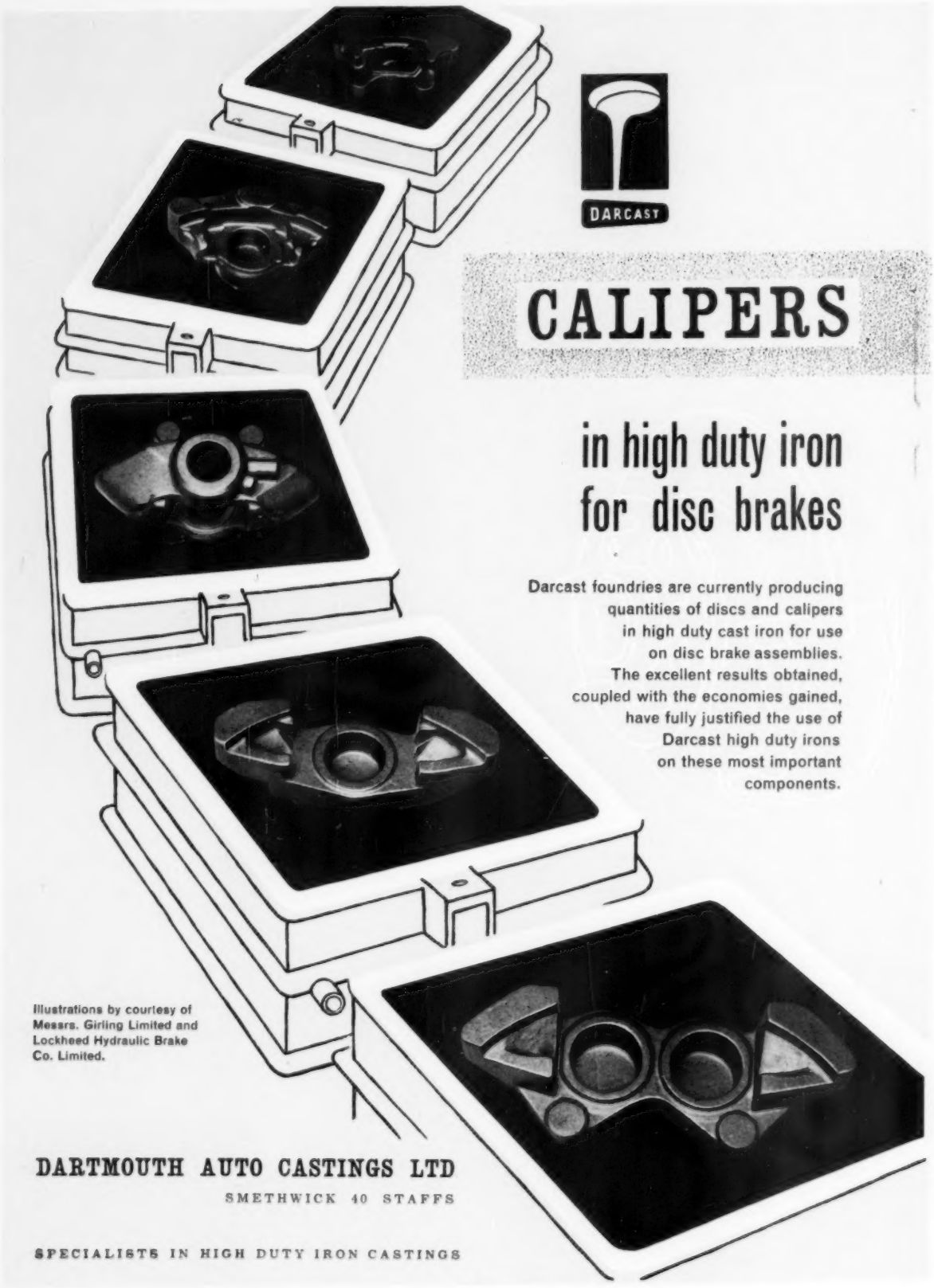

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AUTOMOBILE ENGINEER

DESIGN · MATERIALS · PRODUCTION METHODS · WORKS METHODS

Auxiliary Braking Systems

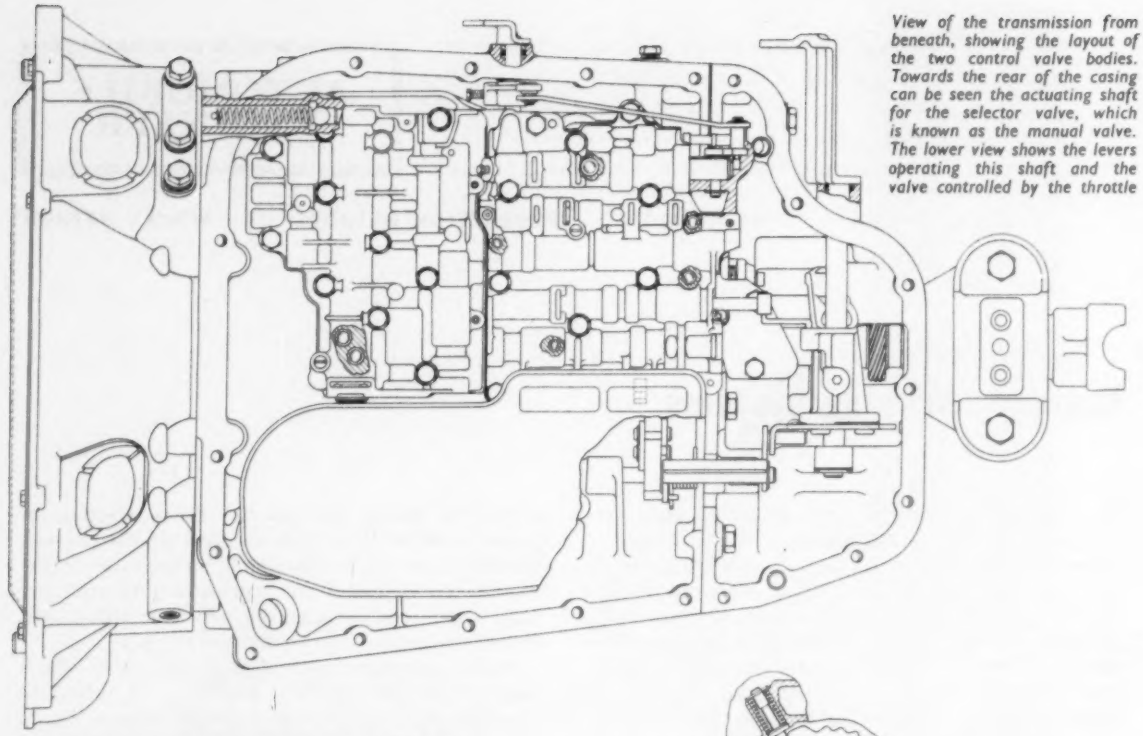
CURRENT discussions between governments in Europe, aimed at rationalizing legal requirements in respect of road transport vehicles, could obviously lead to changes that would have marked effects on design requirements. For example, it is possible that other countries will follow France in making it obligatory for heavy commercial vehicles operated in certain mountainous districts to be equipped with retarders—auxiliary braking systems that are operated entirely independently of the wheel brakes but which do not necessarily have to stop the vehicle. Details of the French law and of some retarders were given in the July 1957 issue of *Automobile Engineer*.

Among the areas that may also become involved are Switzerland and the mountainous districts in Germany, Belgium and some of the Scandinavian countries, so both the "Six" and "Seven" market groups could be affected. Retarders are in use, too, in some districts of the United States. It is obvious, therefore, that manufacturers who export commercial vehicles may, within the next few years, be faced with having to make provision for the fitting of equipment of this type to their vehicles.

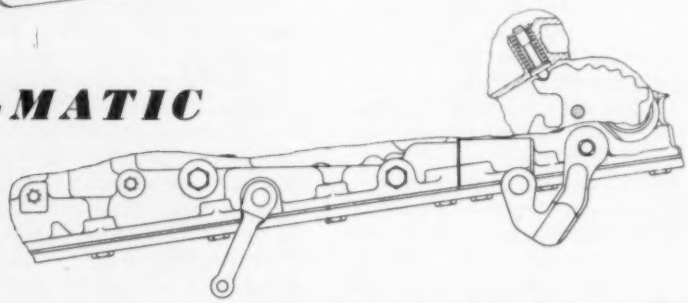
The whole problem should be investigated now, so that, when the need arises, plans to meet the requirements will already have been formulated. Actually, even in Great Britain, there are many types of operation in which savings in respect of the maintenance of the conventional braking systems can more than offset the additional cost of the retarder installation. For example, vehicles used in quarries have to run fully laden downhill for considerable distances, with consequent heavy maintenance bills for their brakes. In these, and other applications throughout the world, there are also incidental advantages provided the heat generated in the retarder is dissipated through the engine cooling system. During long descents, over-cooling of the engine is avoided, with a consequent reduction of sludge formation and corrosive wear. The maintenance of the temperature of the coolant at a reasonably high level is also useful for public service vehicles in which water is used for heating the interior: this is important in countries where twenty mile descents are not unusual. Another factor to be taken into consideration is the current trend towards the employment of relatively small wheels, and the attendant difficulties with regard to heat dissipation from conventional brakes.

British component manufacturers are able to offer a range of different types of retarder. Of these, the simplest and least expensive is the exhaust brake; however, this device cannot be used with certain types of engine and, moreover, it is limited in effectiveness. It is significant that the French regulation, as originally formulated, states that whatever device is used it must be possible in all circumstances, without fail, to select from neutral, or a high gear, a gear ratio sufficiently low for the vehicle speed to be stabilized by the sole action of the retarding device to between 30 and 40 k.p.h. on a slope of 8 per cent. Among other types of retarder that have been used are the eddy current units, in which either permanent magnets or electro magnets are employed. These, unfortunately, are bulky, heavy and costly, and the dissipation of heat presents problems.

Perhaps the hydraulic type of retarder is the most attractive: in this, either the engine coolant is employed as the working fluid or hydraulic oil is used and the heat generated transferred through an exchanger to the engine cooling system. Of these two, the former is the simpler and less expensive, and is therefore particularly suitable for vehicles of about 7 to 12 tons all-up weight. The type in which hydraulic oil is used as the working medium, however, is the more effective with regard to both the speed with which the retarder can be brought fully into operation and the energy absorption capacity for a given size: an absorption rate of 300 b.h.p. is not difficult to obtain, and the ultimate limit is imposed by the capacity of the engine cooling system for dissipating the heat generated. In this connection, it is fortunate that the dissipation capacity of the radiator increases with the speed of the vehicle, as also does the rate of energy input from the retarder. This type of unit is most suitable for vehicles of over 12 tons all-up weight.



View of the transmission from beneath, showing the layout of the two control valve bodies. Towards the rear of the casing can be seen the actuating shaft for the selector valve, which is known as the manual valve. The lower view shows the levers operating this shaft and the valve controlled by the throttle



HYDRA-MATIC

61-05 TRANSMISSION

Part II: The Control System and the Hydraulic Action During Operation of the Unit

THE control system has to fill or empty the fluid coupling at the required times, as well as actuate the three clutches in various combinations. Not only do these operations have to be correlated to the road speed and engine load, but provision has to be made for over-riding the normal control system — when the low or intermediate hold position is selected, or when a kick-down change is desired. Although the actual changes of ratio involve only relatively few hydraulic valves, the control system layout of the transmission is decidedly complex. This complexity is necessary to ensure that the shifts take place really smoothly, and to provide the desirable fail-safe characteristics.

Most of the control valves employed in the system are housed in two aluminium diecastings known as the primary and secondary valve bodies, which are bolted to the underside of the main casing and enclosed within the oil sump. Some of the accompanying illustrations give an indication of the intricacy of the diecastings necessary for these valves and their attendant oil passages. To supplement these illustrations, and to enable the various sequences to be followed, a circuit diagram of the hydraulic system is reproduced. It shows a typical flow condition, of which there are eleven, to cater for all the possible driving requirements.

Before dealing with the various valves and their functions, however, it is appropriate first to describe the governor, since this device is one of the vital links in the chain of control. The governor assembly is mounted on the output shaft, and so rotates at a speed directly proportional to the road speed of the car. It comprises an aluminium housing in which are two spool type valves, disposed radially and mutually at 180 deg; one of these valves is called the primary or G.1 governor and the other the secondary or G.2 governor.

As the G.1 valve moves outward under centrifugal force, one of its intermediate lands clears a port subjected to the output pressure of the oil pump, which henceforth will be called the line pressure. The oil then flows from this port and through a passage in the housing to the outer shoulder of a large-diameter land at the inboard end of the valve. Oil pressure acting on this shoulder overcomes centrifugal force and causes the valve to move inward and partially close the supply port, until the inward and outward forces on the valve are balanced. Opposite the passage just mentioned is another passage, through which the G.1

pressure—proportional to the square of the output shaft speed—is led to the hydraulic system.

G.1 pressure is also applied to the G.2 governor, which operates on exactly the same principle. This governor gives rise to G.2 pressure, also led to the system. Two governors are necessary because of the limited speed range of each that results from the variation of output pressure with the square of the rotational speed. The G.1 governor has the higher output pressure of the two at a given road speed, and so is the more sensitive at low speeds; consequently, G.1 pressure is a controlling influence on the changes between all three forward ratios. Since the G.2 governor becomes effective at higher speeds, it controls only the changes between the upper two gears.

An interesting detail of the governor assembly is the method of transferring the oil to or from its rotating housing. On the hub of the housing are three shallow circumferential oil grooves, connected by internal passages to the appropriate valve ports. In a secondary groove in each of the four lands formed by the oil grooves is a sealing ring of the interlocking type described in Part I of this article. These rings bear radially outwards against a thin steel sleeve pressed into a boss in the rear extension of the transmission casing; three ports in the sleeve communicate with the external oilways, and each of these ports is aligned with the appropriate oil groove on the hub of the governor housing.

Control valves

The system includes a total of 21 control valve units, mostly of the spool type, of which all except five are housed in the two valve bodies already mentioned. These exceptions are the oil pressure regulator valve described earlier, and the coupling feed limit, pressure relief, coupling exhaust and reverse blocker valves. The feed limit valve, of the spring-loaded spool type, is in the oil pump body, adjacent to the pressure regulator valve. It provides, in first and reverse gears, a direct feed to the coupling from the pump, and is controlled by the coupling signal pressure. The opening pressure of this valve is 90 lb/in^2.

To safeguard the system in the event of sticking of the pressure regulator valve, a ball type pressure relief valve is inserted in the line pressure passage in the front wall of the transmission casing. The ball lifts if the pressure exceeds 242 lb/in^2, and by-passes oil to the intake side of the pump. In the carrier of the driving member of the fluid coupling are the duplicated coupling exhaust valves. These are of the poppet type and are spring loaded towards the open position. When the coupling signal pressure is directed to them, they close to seal the exhaust ports. This pressure is applied to the valves through holes drilled radially through the carrier from its hub.

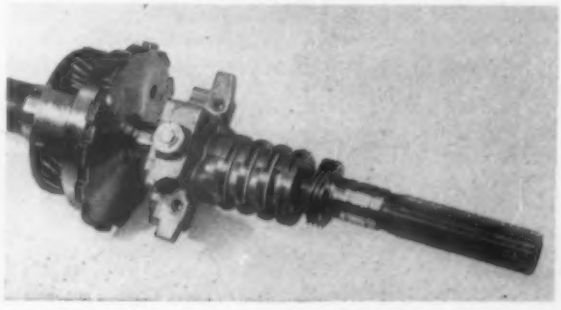
The exhaust blocker valve is another safety measure, the purpose of which is to prevent reverse from being selected at forward road speeds above 10 m.p.h. It is a spring-loaded piston type valve housed in the rear extension of the casing, and is actuated by G.1 pressure. Above the limiting road speed, this pressure overcomes the spring and causes the valve to move. Integral with the piston is a short plunger rod which, when the valve is operated, protrudes from the housing and forms a mechanical stop for the manual linkage, thus preventing the lever from being moved into the reverse position.

We now turn to the various valves comprising the control valve units; the basic one is the manual valve, the position of which is controlled mechanically by the linkage from the selector lever on the steering column. It is of the simple spool type, with three lands, and is moved axially by the linkage. In its housing there are eight oilways, two of which are exhaust passages. Of the others, the line connection is always in circuit, the remainder being brought into or out of use, as necessary, by the movement of the manual valve.

The throttle valve, also of the spool type, acts as a regulator to modify the line pressure in proportion to the throttle opening. It is operated by a plunger and spring, the plunger being mechanically connected, by an external lever, to the throttle linkage. The plunger also functions as the band application valve: when the brake is applied to the second epicyclic train, this valve increases the pressure feed to it as the throttle is opened. In this way, the grip of the band is regulated so that it is always adequate for the torque transmitted.

Gear shifts in either direction between first and second are initiated by the 1-2 shift valve, which senses a balance between the throttle valve, or T.V, pressure and the G.1 pressure from the governor. Similarly, the 2-3 shift valve initiates changes between the upper two ratios. In this case, however, the balance is between the throttle valve pressure and both G.1 and G.2 governor pressures. Both these valves have three portions: the governor actuated spool is at one end, the T.V. pressure spool at the other, and the functional portion is in the middle.

Emptying and filling of the coupling is controlled by the coupling timing valve, which is actuated primarily by the pressure in the feed line for the application of the front clutch. On a change from first to second, it delays the emptying of the coupling until the clutch engagement pressure has built up sufficiently for the torque to be transmitted. When a change from second to third is being effected, the valve is subjected to pressure in the first and



Above: In the main casing, here seen inverted, are the cylinders of the hydraulic accumulator and servo assemblies; the diecasting is very complex. Below: On the output shaft, behind the planet carrier of the rear gear train, is mounted the governor unit, the extended boss of which carries four special sealing rings manufactured of cast iron

third oilway—shown on the circuit diagram—and it moves to refill the coupling immediately after the 2-3 shift valve has moved.

As it name suggests, the band release timing valve performs the function of releasing the band brake on the rear annulus at the appropriate time, on a change from second to third. There is a feed to it from the output side of the compensator, and the valve senses a balance between its spring loading and both compensator and coupling feed pressures. It therefore controls the coupling pressure as well as that to the release side of the band servo.

The oilway from the band release timing valve to the servo is not direct, but is by way of the band release accumulator valve. This latter is a safety device, the purpose of which is to provide a delayed release of the band in the unlikely event of the coupling timing valve sticking during a change from first to second. This valve operates in the following manner: after the 1-2 shift valve has moved, but before the coupling timing valve has done so, the coupling pressure—which is channelled through both these valves—starts to feed the band release line. If the coupling timing valve functions, it causes the coupling and the band release line to be emptied before the band release accumulator valve completes its stroke and so the band remains on. Should the coupling timing valve stick, on the other hand, the accumulator valve completes its stroke and so allows coupling pressure to release the band, thereby causing third gear to engage. If this did not occur, the coupling would be full and the band and clutch both applied, at the same time, so the transmission would be locked.

The pressure boost valve is mounted in tandem with the coupling timing valve and is actuated by the pressure in the line to the front clutch. It is timed to move as soon as the clutch has taken up the drive, and it controls the flow to the underside of the pressure boost piston of the pressure regulator valve in the oil pump. Similarly, the pressure drop valve controls the flow to the line-drop region of the pressure regulator valve. It generates a pressure inversely proportional to that delivered to it by the throttle valve, thereby modulating the line pressure when such action is necessary.

Coaxial with the band release timing valve is the low-throttle control valve. It is sensitive to over-run conditions and operates when the throttle valve pressure falls below 12 lb/in^2. For over-run changes from second to third, it provides an immediate release of the band brake; and on similar changes from second to first, it rapidly exhausts the front clutch to release it.

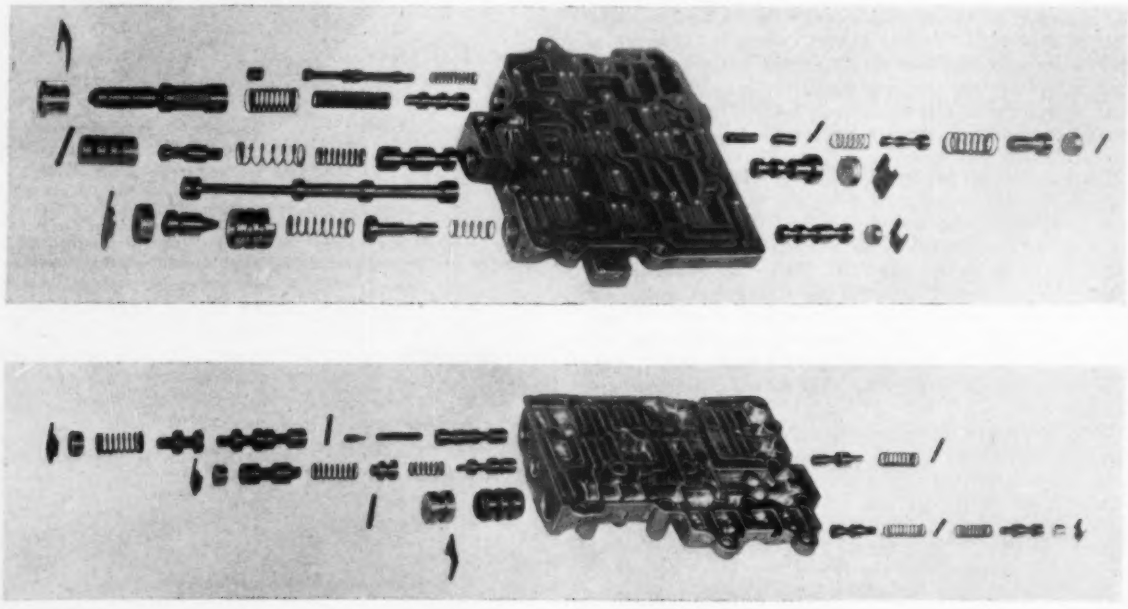
The 2-1 downshift valve and the front clutch exhaust valve are coaxial and operate together for changes from second to first. Of the two valves, the first regulates the exhaust from the clutch, thus allowing it to slip momentarily until sufficient oil has entered the coupling for it to take over the drive without excessive speeding-up of the engine. The duration of the slip is controlled by the second valve which, when the coupling pressure is sufficient, enables the oil to exhaust under full flow conditions from the clutch.

Part-throttle changes down from third to second, and both of the detent—or kickdown—downward changes are initiated by the detent valve. This valve is actuated mechanically by the linkage to the throttle valve, and it transmits T.V. pressure to the 2-3 shift valve in the first instance just mentioned. In the case of the kick-down changes, the valve moves further and also connects the T.V. pressure to the detent passage leading to both the 1-2 and 2-3 shift valves. The remaining control valve is the 2-3 boost valve, which is acted on by the coupling feed and band release accumulator pressures. It allows oil to flow into the pressure boost passages, thus momentarily raising the line pressure to ensure rapid filling of the coupling during a change from the second ratio into third.

Hydraulic action

In this section, each of the possible situations in the transmission, and the relevant hydraulic action, will be considered in turn. The hydraulic circuit diagram will, of course, be different in each case, but it is possible to follow the various operations from the single diagram reproduced. First, however, it should be explained that, whenever the engine is running, hydraulic line pressure is directed to the following valves: manual; pressure regulator; pressure relief;

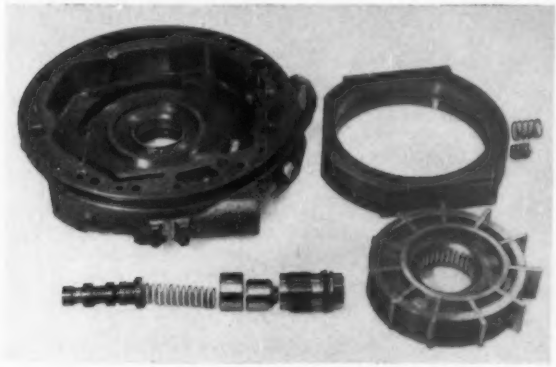
An indication of the complexity of the hydraulic control system is given by these views of the components comprising the primary and secondary valve assemblies. The long valve to the left of the primary valve body is the manual valve which is remotely actuated by the driver, through a linkage



pressure drop; coupling signal, embodied in the coupling timing valve; 1-2 shift; 2-3 shift, at two points; pressure boost; throttle; and coupling feed limit. Line pressure is also routed to the governor.

When the manual valve is set in the neutral position by the selector lever, and the engine is running, line pressure through the coupling signal valve is directed to the coupling exhaust valves, closing them and so sealing the coupling. Coupling signal pressure also opens the feed limit valve in the oil pump body, thereby allowing line pressure to feed through the internal oilway to the coupling. Line pressure at the 2-3 shift valve causes oil to flow through a by-pass orifice into the third gear coupling feed passage, and thence through the coupling timing valve to augment the coupling feed. The release spring holds the band servo out of engagement.

With the manual valve in this position, pressure is transmitted along the line pressure-drop feed passage to the

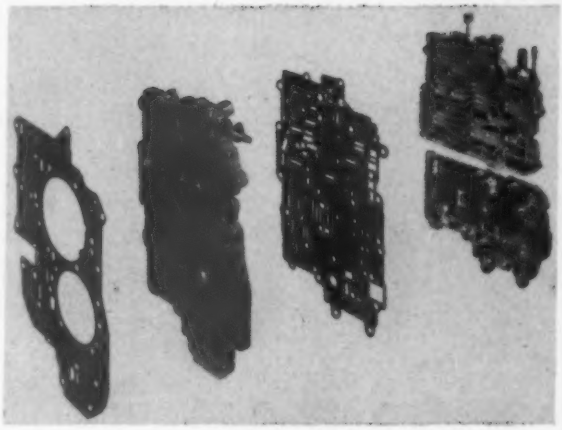


The variable-output hydraulic pump was described in the first part of this article. In this view can be seen the body, rotor, sliding stator member with its two return springs, and pressure regulating valve

pressure boost valve, and thence as line pressure-drop signal oil to the pressure-drop valve. From the pressure boost valve, pressure is also directed into the duct to the boost plunger in the pump regulator valve. The T.V. pressure, acting on the pressure-drop valve, regulates the line-drop signal pressure; the modified pressure is applied to the regulator valve. At small openings of the throttle, the effect of the pressure-drop valve is greatest, whereas at full throttle the valve exhausts and so has no effect on the regulator valve. It follows that the line pressure varies according to the throttle opening, the range being from 122 to 170 lb/in^2.

When the selector lever is moved to the D, or normal drive, position, the manual valve is repositioned to allow line pressure to enter the drive circuit. Oil can then flow from the drive circuit to the band application valve and to the 1-2 shift and primary compensator valves. At the band application valve, the oil travels through an orifice from the drive line into the band apply line and thence to the band servo. As the throttle is opened, the band application valve opens, thereby increasing the flow to the servo and causing its action to be accelerated.

Pressure from the coupling signal valve acts on the feed limit valve, opening it to allow line pressure to be applied directly to the coupling feed passage. The oil fed from the drive circuit to the 1-2 shift valve flows through it to become what the manufacturers call first gear oil, which then flows to the 2-3 shift valve, where it becomes first and third gear oil. This, in turn, is routed to the end of the coupling signal valve to assist the spring in holding this open; in this way, since it prevents the coupling from emptying, it performs a timing function. The line pressure is controlled in



Sealing the lower ends of the accumulator and servo cylinders is a diecasting which, with the appropriate gaskets that are also shown here, is sandwiched between the two valve bodies and the main casing

the manner already described for the neutral condition. Once the vehicle is moving, of course, the line pressure fed to the governor is modified by the action of the two valves in this, and so emerges as G.1 and G.2 pressures.

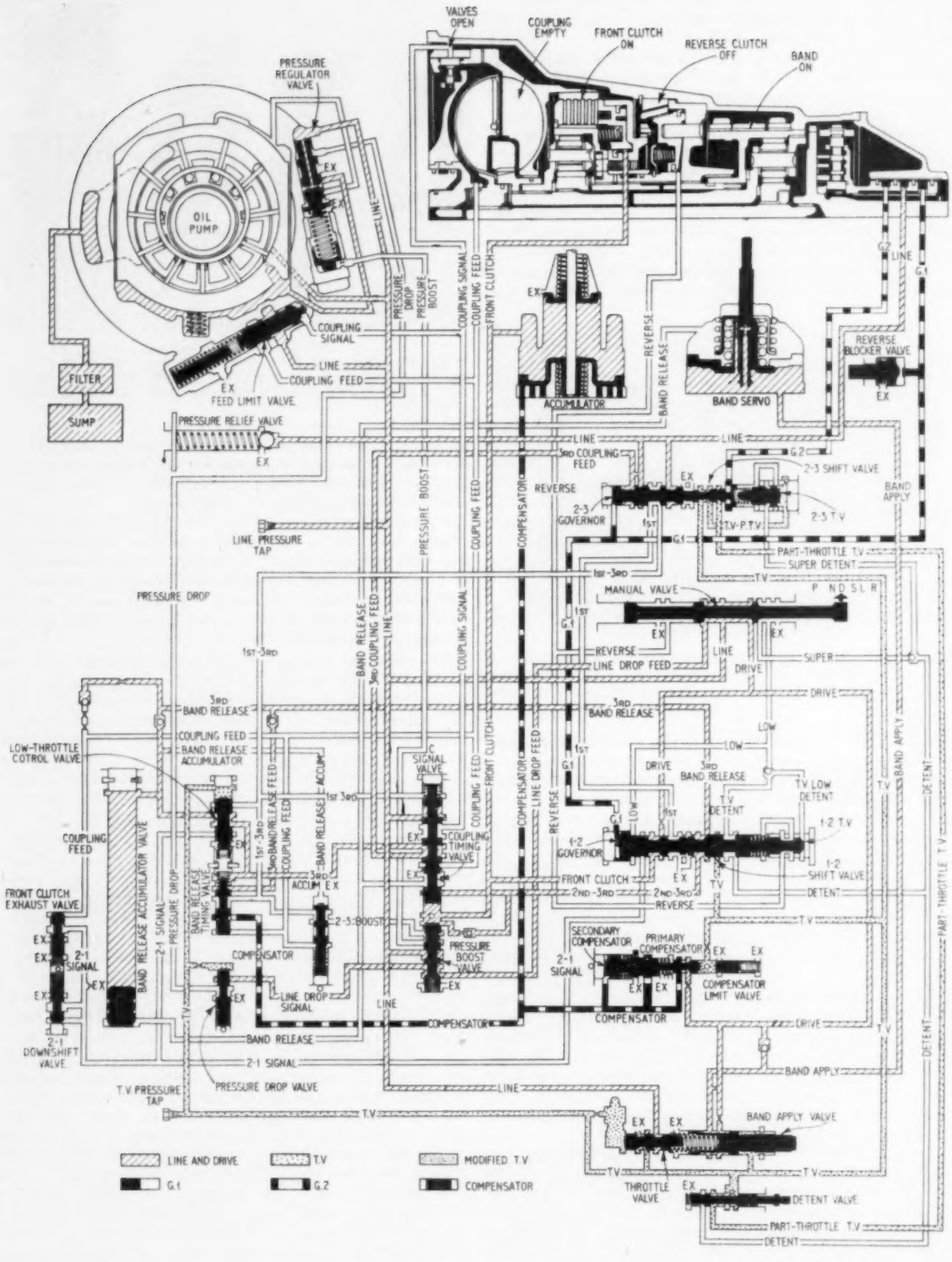
First and third gear oil is also directed to the low-throttle control valve. If the T.V. pressure is below about 40 lb/in^2, this valve transmits the oil to the band release accumulator, to charge it for use during a shift from first to second. Additional passages convey first and third gear oil to the band release timing valve and the 2-3 boost valve for the change from second to third.

The drive oil led to the primary compensator valve is acted on by T.V. pressure in this valve, to emerge as what is termed compensator oil, at a pressure commensurate with the engine torque. It is then routed to the front clutch accumulator and to the band release valve. The first of these is, of course, brought into use for the first to second change, and the other during the second to third change.

As the speed of the vehicle increases, the G.1 pressure becomes sufficient to overcome the combined resistance of the 1-2 shift valve spring, the 1-2 T.V. spring and the modulated T.V. pressure. The shift valve therefore opens, allowing drive oil to enter the passage to the front clutch. At the same time, T.V. pressure to the T.V. modulating portion of the 1-2 shift valve is cut off by the valve spool; in addition, the first and third gear oil that previously charged the band release accumulator is exhausted through the 1-2 shift valve. It then becomes known as second and third gear oil, and provides an auxiliary feed to the front clutch, by way of the ball check valve adjacent to the coupling timing valve.

As well as applying the clutch, the drive circuit oil from the 1-2 shift valve moves the coupling timing valve against its spring. Consequently, the coupling signal oil and coupling feed oil passages are cut off. The exhaust valves on the coupling then open and it empties under centrifugal force. At the same time, the front clutch oil pressure also moves the pressure boost valve against line pressure and its spring, thus preventing the line pressure from entering the pressure boost and line pressure-drop signal passages. Instead, the second of these is fed by line pressure-drop feed oil, by way of the manual valve. The result is a reduced line pressure, which varies between 74 and 105 lb/in^2 according to the throttle opening.

Reference has already been made to the effect of compensator pressure on the manner in which the front clutch is applied. The purpose of using the front clutch oil to



This diagrammatic illustration of the hydraulic control system shows the circuits in use during a normal change from top to second gear. Since all the oilways and valves are annotated, the other conditions of operation of the transmission, which are described in the text, can be followed

move the pressure boost valve is that this oil acts as a signal to the effect that there is sufficient clutch pressure to transmit the second gear torque, and hence for the line pressure to be allowed to drop. Additionally, this arrangement prevents a drop of pressure in the band servo until the change to second gear is completed; the torque on the band in first gear is, of course, greater than that in second gear, and a premature fall of pressure could result in the band slipping when first gear is still in operation.

As was explained in the description of the control valves, the band release accumulator valve provides a safety feature, to prevent locking of the transmission if the coupling timing valve should stick on a first to second change. In this latter event, the oil exhausted from the accumulator passes through the low-throttle control valve into either the first and third oil passage or the third gear accumulator exhaust passage, past the coupling timing valve. This releases the band and causes the transmission to shift into third. If the coupling timing valve functions correctly, oil is exhausted from the accumulator along the band release passage to the coupling timing valve. As a result, third gear coupling feed oil, delivered from the line, can pass from the timing valve to the low-throttle control valve; if the T.V. pressure is more than about 40 lb/in^2, this last valve opens to allow the accumulator to be recharged.

When the road speed in second gear has increased sufficiently, the combined effect of G.1 and G.2 pressures and the thrust of the 2-3 shift valve spring overcomes the modulated T.V. pressure and the regulator spring of the T.V. portion of the valve. The consequent opening of the valve causes line pressure to be applied to the first and third gear coupling feed passages. At the same time, T.V. pressure is cut off from the T.V. regulating portion of the valve.

First and third gear oil pressure moves the coupling timing valve against the front clutch pressure, so allowing coupling signal oil to close the coupling exhaust valves. The third gear coupling feed oil passes through the coupling timing valve into the feed line to the coupling, which is therefore filled. Simultaneously, second and third oil flows through the coupling timing valve to become band release oil, the pressure of which causes the band brake to be disengaged. At relatively large throttle openings, where the line pressure exceeds 90 lb/in^2, coupling signal oil opens the feed limit valve to accelerate the filling of the coupling.

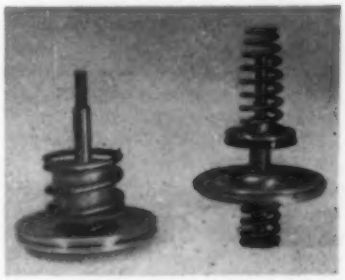
It is clear that, during part-throttle changes from second to third, the release of the band must be timed in relation to the filling of the coupling. If the T.V. pressure is below 40 lb/in^2, the position of the low-throttle control valve is such that first and third oil flows directly into the band release accumulator passage. This oil then performs two functions, one of which is to move the 2-3 boost valve against its spring. In this way, the first and third oil is allowed to flow through the 2-3 boost valve, and along the 2-3 boost passage to the pressure boost valve, which produces a sudden rise in line pressure to ensure quick filling of the coupling.

The second function of the band release accumulator oil is to stop the movement of the accumulator valve and to open the ball check valve between the band release accumulator passage and the third gear band release passage, thus ensuring the rapid flow of the band release oil. As the coupling feed pressure builds up, it assists the spring in restoring the 2-3 boost valve to its closed position. This action shuts off the feed to the pressure boost valve and so allows the line pressure to return to its normal third gear value of 74 to 105 lb/in^2.

If the T.V. pressure exceeds 40 lb/in^2, the low-throttle control valve is closed to the first and third oil which, however, is applied to the band release timing valve. The coupling fills under normal line pressure and, when the pressure in it has risen sufficiently, the band release timing valve is opened and allows the first and third oil to enter the third gear band release passage. This oil opens a ball check valve in the passage, which enables it to flow to the 1-2 shift valve; it then becomes second and third oil, and travels to the coupling timing valve, where it is directed into the band release line. Before the band release timing valve moves to the third gear position, oil from the band release accumulator exhausts through the low-throttle control valve and the coupling timing valve.

If the vehicle is travelling in third gear at less than about 33 m.p.h, a downward change into second can be obtained by partial depression of the accelerator. When the detent valve has been moved sufficiently by the actuation of the throttle valve linkage, it permits T.V. pressure to be applied to the part-throttle T.V. passage. Since the 2-3 shift valve is open, part-throttle T.V. oil can flow to the end of the T.V. regulating part of the valve, thereby causing the shift valve to move.

As this happens, first and third oil and third gear coupling feed oil from the 2-3 shift valve are cut off. In consequence, the coupling timing valve moves to the second gear position,



The piston assemblies embodied in the band brake servo and front clutch accumulator. A feature of the servo unit, left, is that it embodies two springs; the accumulator has two coaxial pistons

which results in the exhausting of the coupling and the band release oil. Drive oil applies the band, so causing the change into second gear to be effected.

A kick-down change from third gear to second is available at road speeds below 55 m.p.h. Full depression of the throttle pedal results in a corresponding full opening of the detent valve, which exposes the detent passage to T.V. pressure. In this passage is a ball check valve, past which the oil flows to the 2-3 shift valve. Here, the detent pressure overcomes the G.1 and G.2 pressures and the spring loading, and the shift valve consequently closes, initiating the change into second gear as already described.

When the speed falls sufficiently in second gear, with a light or closed throttle, the T.V. pressure overcomes the G.1 pressure and so causes the 1-2 shift valve to move, thus initiating the change down to first. The movement of the valve cuts off the supply of drive oil to the front clutch. The oil from the front clutch and accumulator is exhausted through the shift valve into the 2-1 signal passage. Because of the low T.V. pressure, however, the low-throttle control valve is open, and the oil in the 2-1 signal passage can exhaust through it, thereby permitting rapid emptying of the clutch system. As the shift valve closes, drive oil feeds into the first gear oil passage, and so to the closed 2-3 shift valve, where it is directed into the first and third gear passage. This passage takes it to the coupling signal valve, which it repositions for refilling the coupling.

When the throttle opening is relatively large, however, the oil exhausting from the front clutch through the 2-1 signal passage has to pass through the 2-1 downshift valve, because the low-throttle control valve is then closed. The 2-1 downshift valve restricts the flow of the exhausting oil so that the clutch does not disengage until the coupling has

filled sufficiently to take up the drive. The 2-1 signal oil is also applied to the front clutch exhaust valve until the coupling pressure has built up sufficiently, whereupon the valve moves to complete the exhausting of the oil. Below about 18 m.p.h. in second gear, a kick-down change to first is obtainable. Full depression of the accelerator opens the detent valve; T.V. pressure is, therefore, applied to the detent passage, and so to the T.V. regulating portion of the 1-2 shift valve. As a result, the shift valve closes against G.1 pressure. The release of the front clutch and the refilling of the coupling then occur as just described in connection with light-throttle changes.

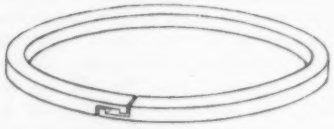
Movement of the selector lever to the S position brings in what is called the super range, in which second gear is held regardless of road speed, unless this exceeds about 55 m.p.h. In this latter case a change into third occurs irrespective of the throttle opening, as it would at full throttle in the normal drive range. The hydraulic action is as previously described for drive range second gear, with two exceptions. Of these, the first is that the line pressure is applied by the manual valve, through the super and super detent passages, to the 2-3 shift valve, so that a change to third is prevented unless G.1 and G.2 pressures reach a high value. Secondly, in its S position, the manual valve cuts off the line-drop feed passage to the pressure boost valve. Consequently, the normal pressure-drop signal cannot be given, and line pressure is, therefore, maintained constant at about 105 lb/in^2, in both second and third gears, regardless of the throttle opening employed.

For holding first gear, irrespective of the throttle opening or road speed, the selector lever is moved to the L, or low range, position. If this is done while the transmission is in second or third gear, first will not engage until the road speed falls below about 31 m.p.h. It is worthy of note that, since this range is only intended for low-speed manoeuvring or for emergency retardation on steep inclines, no change-up to second will subsequently occur, even if the road speed exceeds the figure mentioned.

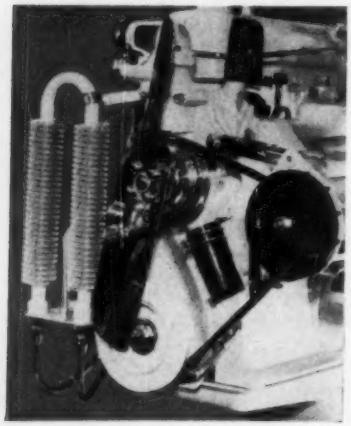
In the L position of the manual valve, line pressure is transmitted by the valve to the low gear oil passage as well as to the super one. The low gear oil is applied to the governor portion of the 1-2 shift valve to oppose G.1 pressure there. It is also directed past a ball check valve to the end of the T.V. regulating portion of the shift valve, where it applies an additional load to the valve against governor pressure. Control of the line pressure is effected as when first gear is engaged in the normal drive range.

The remaining position of the selector lever is, of course, for reverse. When R is selected, line pressure is directed to the manual valve and to the governor, as well as the following control valves: throttle; coupling timing; pressure regulator; pressure boost; coupling feed limit; and 2-3 shift. Drive, super and low oils are exhausted at the manual valve.

Line pressure at the coupling timing valve causes oil to enter the coupling signal passage, and so to close the coupling exhaust valves and open the coupling feed limit valve; the coupling therefore fills. From the manual valve, line pressure is directed to the reverse line, through which oil flows to the reverse clutch, thereby holding the front annulus gear. Reverse oil is also applied to the T.V. regulating portion of the 1-2 shift valve, to prevent this from initiating a change. Line pressure performs the same function at the 2-3 shift valve. In addition, the manual valve directs line pressure to the line pressure-drop feed and line pressure-drop signal passages. This supply, together with the line pressure applied directly to the pressure boost valve, results in a variable line pressure similar to that obtained in first gear.



In Part I of this article, reference was made to the use of a number of sealing rings of unusual design. This illustration shows the interlocking ends of these rings



A gilled tube type of oil cooler forms part of the installation of the transmission. Good cooling should result from its situation in front of the engine

Four-way Socket Outlet

A RECENTLY introduced item of electrical equipment should prove of value in factories, workshops and laboratories It is the Briticent four-way, 13 amp socket outlet marketed by British Central Electrical Co. Ltd, Briticent House, 6 to 8 Rosebery Avenue, London, E.C.1. This new unit is designed on similar lines to the company's successful 5 amp socket outlet and is suitable for the flat pin type of plug. Safety features include the embodiment of a fuse on the line side, and the shuttering of each outlet.

The body is of moulded hard rubber or neoprène; both versions are said to be unbreakable—a claim is made that even running over it by a heavy vehicle will not cause damage—and the neoprene body is highly resistant to oils and corrosives. All the contacts are formed from continuous strip brass and are embedded edgewise in the moulding, and the connection arrangements are based on the ring main principle. For security, the incoming mains lead is looped completely round a central insulated post within the body. The unit can be either attached by screws to a flat surface, or suspended by a leather thong from, for example, a wall. A descriptive leaflet is available from the makers.

Electronic Control Units

THE application of electronic controls in the oil and chemical industries is increasing considerably, and it is clearly essential that no fire risk should follow from the use of these controls in areas where inflammable gases may be present. To meet this need of complete safety, Elcontrol Ltd, Wilbury Way, Hitchin, Herts, is able to supply many of its standard control units in forms suitable for operating in hazardous areas. Details of these units and the type of protection provided are given in Data Sheet FP, Issue 1, 11/60, copies of which are obtainable from the manufacturers.

CASTING ALUMINIUM BRONZE

Some Notes on General Principles and Practical Aspects

G. FITZGERALD-LEE, F.R.Econ.S, M.I.E.I, A.R.Ae.S.

CASTING aluminium bronze is not difficult providing that its specific properties and characteristics are taken intelligently and fully into account. Application of the correct design and technique always gives good results with superior finish, high mechanical properties and accuracy of detail. In order to achieve success, the first principle is to use only materials of high purity for the melt: as the base, a copper as near oxygen-free as possible should be used, or, if due allowance is made for the oxygen content, good quality low-oxygen ingots or bars. To combat high shrinkage, adequate feeders and risers should, of course, be provided; and if the formation of folds, seams and shots is to be avoided, there must be no excessive agitation or turbulence during melting, stirring being limited to only enough to ensure mixing the aluminium with the copper. Careful pouring also minimizes the formation of aluminium oxide which, once formed, may necessitate the use of powerful deoxidants for its removal. The absorption of gases during melting must be guarded against, and there may even be liberation of gases during solidification, giving porous castings; another danger is the possibility of the production of a coarse, brittle structure caused by self-annealing, which occurs when certain types of castings are not cooled fast enough in the moulds.

Melts are usually compounded from virgin metals and scrap, but better results are obtained by first preparing the alloy in pig or ingot form and then remelting; this minimizes the occurrence of gas absorption or the entrapping of oxides, as well as controlling the melt better. The latter procedure is well suited to the production of intricate castings in complex alloys. G. K. Dreher[1] emphasized that small differences in the amount of aluminium in the composition of the melt can cause large variations in properties, so that the exact control of constituents, which can be obtained by this method, is important. Remelted scrap metal, even though of high purity, may yet contain oxide to an extent deleterious to aluminium bronze. On the question of the amount of scrap used in a casting melt, M. T. Ganzauge[2] stated that the proportion of scrap used in the composition of the melt for intricate castings should be less than 30 per cent, and that for simple castings 60 per cent should be the limit. E. R. Thews,[3] however, said that the limit should, in all cases, be 15 per cent. Thus, it can be seen that opinions differ widely.

Commercially pure aluminium can be added in ingot form or, preferably, as a master alloy containing 50 per cent copper and 50 per cent aluminium. Adding aluminium to molten copper causes the formation of Cu_2Al and aluminium oxide, with a consequent rise in temperature; this rise, causing large amounts of dross which could become mixed with the melt, is minimized, with proportionately better results, by using a 50/50 alloy. In complex alloys, the requisite amounts of iron, nickel and manganese are commonly added during the preparation of the master 50/50 alloy. If a master alloy is not to be used, iron can be introduced into the molten copper, with the aluminium, as sheets or strips, the rise of temperature in this case assisting in taking the iron into the melt. Nickel can be added as 50/50 nickel-copper shot or, after the copper, as nickel shot. Manganese, in the form of a master alloy of copper containing 30 per cent manganese, is added just before the aluminium, because it is a deoxidizer, and therefore eliminates most of the cuprous oxide. Any kind of furnace, except the induction electric type but including reverberatory furnaces, which is suitable for brass or bronze can be used for aluminium bronze. Melting should be effected as quickly as possible because there is then less chance of gas absorption.

Fluxes

It is still debatable as to whether fluxes should be used or not, and, if so, just what their purpose should be. The general concensus of opinion at present suggests that, so far as possible, fluxes should not be used—when used, they are difficult to remove and could cause slag inclusions in the castings. Active slag covers, such as bottle glass and borax salt mixtures, perhaps with sal-ammoniac, manganese sulphate or fluorides added, are practically essential when melting dirty charges of scrap metal, but such covers cause corrosion of crucibles and furnace linings. Charcoal, which is in this case a good deoxidizer, can be used providing that it is not allowed to stay for long on molten aluminium bronze with a large percentage of iron, because carbon absorption may thus occur. Certain mixtures of salts and deoxidants are also used as fluxes and are added to aluminium bronze before it is poured; one of these has four parts of manganese sulphate to one of powdered magnesium, of which 0·05 per cent is added at a time, by an inverted plunger below the surface of the melt. Some cleansing can also be effected by adding sodium carbonate in the same way, or by a mixture of powdered pumice and salt put into the crucible before adding the charge.

Only a few deoxidants are able to reduce alumina, Al_2O_3; some help to coagulate it, and cause it to float to the surface, so that it can be removed. For aluminium bronze, manganese—although it is not very active—in residual amounts of up to 1 per cent, is the commonest deoxidizer used; with it, about 0·2 per cent of magnesium—a good deoxidizer and desulphurizer, reducing even alumina — is commonly employed. E. R. Thews[3] recommended the use of phosphorus as a deoxidant, but most authorities do not advocate the use of this element in aluminium bronze because, although it is the commonest deoxidizer used for copper alloys, it tends to cause the separation of phosphides in aluminium bronze, adversely affecting shock-resistance and ductility, and causing an inclination to hot-shortness. Silicon also has a bad name as a deoxidizer because when large quantities remain in the alloy, silicon may decrease ductility and shock-resistance, although certain copper-aluminium-silicon alloys are of considerable use.

Furnace gases absorbed during melting can create serious problems when aluminium bronze is cast—only hydrogen has any solubility at all in the liquid or solid metal. But a good deal of the unsoundness of castings is caused by the reaction of hydrogen, evolved on solidifying, with the oxides present. In a range of copper-aluminium alloys with up to 8·1 per cent aluminium, P. Röntgen and F. Möller[4] found that a progressive reduction in the solubility of hydrogen occurs with increase of aluminium until, at about 7 per cent

aluminium content, the solubility is only about half that encountered with copper; and, as with copper, there is a distinct difference between the liquid and solid solubilities; some results of these investigations are shown in Fig. 1. The same authorities found that the monoxide or dioxide of carbon is, like nitrogen, insoluble in copper-aluminium alloys having up to 0·3 per cent of aluminium. E. Raub and A. Schall[5] stated that aluminium bronze absorbs sulphur dioxide to form aluminium oxide and aluminium sulphide; these do not recombine on cooling through the freezing range but remain in the metal or slag.

Pouring and casting

Pouring and casting techniques depend mainly on the final products—whether they are ingots, billets, sand or die castings. There need be no fear of oxide inclusions if the metal is poured correctly, because oxide inclusions generally start from the film covering the molten metal and from those formed around the metal during pouring. To obviate the possibility of such films being included in the metal during pouring, with the resultant defects in the castings, the melt should be skimmed just before it is poured into the mould. Feeding should be carefully effected, to minimize problems caused by contraction and shrinkage. Although many authorities emphasize the need for large feeders and risers, W. Claus and F. Goederitz[6] and N. B. Pilling and T. E. Kihlgren[7] showed that when aluminium bronze freezes, the contraction is definitely less than for several other copper alloys. Shrinkage problems in aluminium bronze are due mainly to the fact that there is only a few degrees difference between the liquidus and solidus temperatures, giving a short solidification range. The weight of a 10 per cent aluminium bronze at freezing point is 0·241 lb/in^3, which is very much less than that of most copper alloys not containing aluminium; the total volumetric shrinkage is 11·2 per cent—more than that of copper, but less than that of manganese bronze, nickel-silver or ordinary brass; the freezing shrinkage is 4·1 per cent, and the remarks already made in connection with volumetric shrinkage apply also in this case; the volumetric solid shrinkage is 7·1 per cent and linear solid shrinkage 2·37 per cent, both more than most other copper alloys. For the pattern-maker's shrinkage allowance of $\frac{5}{32}$ in/ft, the linear, solid shrinkage is, of course, the guide.

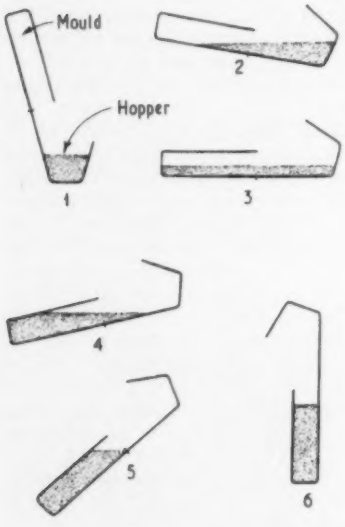


Fig. 2. These diagrams show the principle of operation on the Durville process for pouring aluminium bronze. The numbers 1 to 6 represent the stages in the pouring process

The best-known specifications for aluminium bronze for both sand and die casting are B.S.S.1400-AB1-C and D.T.D.174A. Generally, the alloy contains 9·5 per cent of aluminium, 2·5 per cent iron, up to 1 per cent each of nickel and manganese, and the remainder, of course, is copper. This metal has a 0·1 per cent proof stress of 11-14 ton/in^2, tensile strength of 32-37 ton/in^2, elongation of 20-40 per cent and hardness of 90-140 D.P.H. Another well-known sand and die cast alloy, to AB2-C of the same B.S. specification and to D.T.D.412, contains the same amount of aluminium, but with 5·5 per cent of nickel, 4·5 per cent iron and up to 1·5 per cent of manganese; this gives a proof stress of 16-20 ton/in^2, tensile strength of 40-45 ton/in^2, elongation of 12-20 per cent, and 150-200 D.P.H. A third series of hard casting alloys, for service involving heavy compressive loads—their abrasion resistance is also high—contain

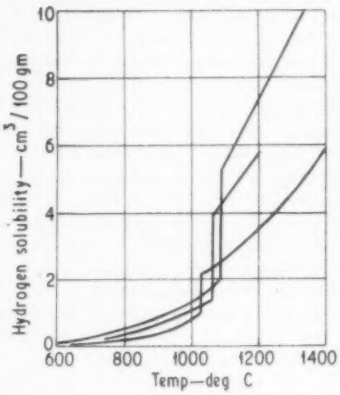


Fig. 1. Curves[1] demonstrating the solubility of hydrogen in copper and copper-aluminium alloy materials

12 per cent of aluminium, and from 5 to 8 per cent of iron, nickel and manganese; the proof stress in this series ranges from 28 to 35 ton/in^2, tensile strength 32-40 ton/in^2, elongation 2-5 per cent and hardness 200-300 D.P.H.—nearly twice the hardness of fine grey cast iron.

Practice

The main differences between sand casting aluminium bronze and other copper alloys lie in the gating and the large feeders and risers needed. Risers much the same as those used for steel are employed. The whole procedure has to be carefully controlled. Much depends on good design in respect of simplicity, the avoidance of sudden changes of section, the elimination of any corners or pockets likely to entrap oxides, and the correct use of chills. Gating should allow the molten metal to fall gently to the bottom of the sprue, from which, entering the mould without undue agitation, it can float any dross or dirt up in front of it into the risers. A horn gate is not satisfactory because a fountain effect is produced when the metal gushes up into the mould, taking air bubbles and dross with it. J. E. Crown[8] and M. T. Ganzauge[2] advised the use of inverted horn gates tapering open towards the casting and situated as far away from the core as possible, and this is probably the best type. It may incorporate steps to prevent the mould sand from being washed away and also to break the flow of the metal, or spiral, inclined planes to take the metal quiescently to the bottom of the mould.

To facilitate flow, the metal used for feeding should be superheated by at least 150 deg C, but the temperature must also remain the lowest consistent with free flow to all parts of the castings, because excessive heat increases the likelihood of gas absorption in melting and shrinkage on cooling. To help the maintenance of high temperature in moulding, H. F. Taylor and W. C. Wick[9] described the use of heat-

Table—LIQUID AND SOLID CONTRACTION OF COPPER ALLOYS[7]

Alloy and composition per cent	Weight of liquid at freezing point lb/in³	Total volumetric shrinkage per cent	Freezing shrinkage per cent	Solid shrinkage	
				Volume per cent	Linear per cent
Aluminium bronze Cu 90, Al 10	0·241	11·2	4·1	7·1	2·37
Copper, deoxidized	0·285	10·7	3·8	6·9	2·32
Bearing bronze Cu 80, Sn 10, Pb 10	0·293	11·2	7·3	3·9	1·29
Red brass Cu 85, Sn 5, Pb 5, Zn 5	0·287	10·6	6·3	4·3	1·44
Brass Cu 70, Zn 27, Pb 2, Sn 1	0·271	12·4	6·4	6·0	1·98
Manganese bronze Cu 56·7, Zn 40, Fe 1·3, Sn 0·5, Al 1, Mn 0·5	0·261	11·5	4·6	6·9	2·32
Nickel-silver Cu 65, Ni 20, Zn 15	0·279	12·1	5·5	6·6	2·19

insulating pads and of risers moulded in gypsum; covering the feeder heads with chopped straw or other heat-insulator also helps. Chills assist in overcoming both shrinkage difficulties and the formation of coarse, brittle structures resulting from the slow cooling of heavy sections. J. E. Crown[8] found that by using chills, scurf and oxides can be made to collect on the surface of the metal at the chills, thus only light machining or grinding is needed to give a clean, sound surface. According to F. Hudson,[10] the best material for chills appears to be carborundum, because those made of ferrous metals may cause blowing because of their sweat when they are clean and the rust on them if they are at all corroded.

Moulds, with plenty of ventilation to allow gases to escape, may be of either green or dry sand, but for pressure-service or complex castings, only dry sand moulds should be used, to obviate, or at least minimize, the formation of steam. The cooling of the casting must, in all cases, be rapid, and to effect this with thick castings a fine water spray should be used in such a way that it cools without the sudden quenching, which would cause a hard, brittle structure difficult to machine. Slow cooling could well result in self-annealing of the metal, and F. Hudson[11,12] states that the rapid cooling of castings with about 10 per cent of aluminium content is as undesirable as self-annealing, therefore the highest aluminium content normally used is 9·5 per cent, *c.f.* B.S.S. mentioned before. A further precaution is to add 3 per cent of iron, which inhibits grain-growth and thus prevents the occurrence of the undesirable self-annealed structure of castings that have been cooled slowly.

Aluminium bronze is not usually pressure die cast because the conditions of this process are too turbulent; but gravity die casting is widely used. Die cast products are strong and stable, and production costs are relatively low because the dies and cores are so little attacked by the alloy. The metal is harder, stronger and more dimensionally stable and corrosion-resistant at high temperatures than many die cast materials with lower melting points. In the designs for gravity die castings, cored holes should not, as a rule, be less than $\frac{3}{16}$ in diameter, otherwise the cores may be burnt; smaller diameter holes can, however, be used providing that they are not too deep. The dies and cores naturally get hotter during working, and they should be cooled periodically by plunging the moulds into water, with colloidal graphite in suspension, at a temperature of about 225 deg C; the graphite film gives protection to the moulds during casting. Instead of the colloidal graphite, however, the dies can be brushed or sprayed with sodium silicate solution, which, when it dries, leaves a hard film which fills the pores and also prevents the castings from sticking and the difficulties subsequently entailed.

The best method for pouring aluminium bronze is one that has not been much modified since it was devised in 1913 by P. H. G. Durville.[13] It was described by him in 1927: the crucible from which the metal is poured is placed in line with the mould on a mounted stage which rotates freely; and a refractory launder connects the crucible and the mould, Fig. 2. Molten metal is put into the crucible, the oxides are removed by skimming and then the melt is poured by rapid but smooth rotation until the mould has been turned through 180 degrees. Pouring aluminium bronze by this method usually takes from 6 to 20 seconds, depending on the size of the ingot; feeding takes longer and requires particular care. To minimize the initial chill of the ingot surface, the moulds should be covered with a film of lamp black. Oil-based mould dressings should not be used when casting aluminium bronze by this method, since they give only limited protection to the moulds, and the gases resulting from their use cause excessive agitation. The Durville process is used for producing ingots to roll into strip and sheet, and also billets for rods, wires and tubes. Cast iron moulds are employed and they may be either solid or split, and copper is commonly used for facing them. Solid moulds should be tapered about $\frac{1}{16}$–$\frac{1}{8}$ in per foot, to allow the withdrawal of the ingots, or it may be preferable to use untapered split moulds.

Centrifugal casting, with cast iron or steel permanent moulds, is often the best method of producing cylindrical parts, with uniform internal diameters, such as gear blanks and bushes. This method gives castings with fine structures, which is, of course, important in the case of products, such as gear wheels, in which the surface of the casting has to bear the brunt of service. Because the rotational speeds need not be so high, large castings are often easier produced by the centrifugal process; yet, at the other extreme, providing that high speeds are used, the process is suitable for the production of bushes of only 2 in diameter.

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The Analogue Computer

Elementary Fundamental Principles and Applications to Engineering Design, Production and Testing

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As every engineer is aware, knowledge of the basic principles of operation of any tool, especially if it is complex, is essential for its application with optimum effect. This article explains in simple terms, for those who are not well versed in electronics technology, how analogue computers work. The aim is at helping designers and development and production engineers, so far as intelligent application of computers to the many complex problems that they meet in practice is concerned.

ANALOGUE computation in one form or another, has been employed for a very long time. Computation can be interpreted as doing arithmetic, and the term analogue implies that the numbers involved in the arithmetic are represented not simply as figures but by some easily measured physical quantity, such as length: for example, the numbers 8 or 11 might be represented by 8 in or 11 mm respectively; alternatively, electrical voltage, 8 V, 1·1 = 11/10 V or any other convenient quantity could be used.

In a simple way, the addition of two numbers such as 8 and 11 could be performed by cutting two pieces of wood, one to a length of 8 in and the other to 11 in long, placing them end to end, and measuring the total length to be 19 in. In practice, the result would probably be, say, 18·99 in, and this demonstrates one disadvantage of the analogue technique, namely, that it is subject to errors of measurement. However, the electronic analogue type of computer is, in fact, capable of acceptable accuracy, usually well within the limits of that of the data initially available for the solution of the problem.

Work on the development of analogue computers received great impetus during and after the Second World War, in connection with applications such as gun-laying predictors. In the early applications, mainly mechanical principles and components were employed, but advances in electronics subsequently led to the evolution of the modern general purpose electronic analogue computer. This type, widely used in the aircraft industry, is sometimes also known as a simulator, though this term usually implies a machine intended to solve only one particular type of problem.

General purpose analogue computers can be used for a very wide range of problems, for example, the solution of sets of simultaneous algebraic equations. Their most common application, however, is to the solution of the differential equations that have to be dealt with in the study of most dynamic systems.

In such equations, one or more dependent variables $y_1, y_2, \ldots y_n$ are unknown functions of a single independent variable x, and a set of n equations exists, each of the form

$$f(y_1, dy_1/dx, d^2y_1/dx^2, \ldots d^my_1/dx^m, y_2, dy_2/dx \ldots . y_n, dy_n/dx, d^2y_n/dx^2, \ldots d^my_n/dx^m, x) = 0$$

where the function may contain powers, multiples and other functions of the variables and their derivatives. The appropriate number of initial conditions or boundary values are, of course, also necessary for the solution of these equations.

In the electronic analogue computer, the dependent variables y are represented by voltages, and the independent variable x is almost always represented by time. So far as the equations of dynamic systems are concerned, the independent variable is usually time in any case. In the operation of the computer, the variations of these voltages with time, displayed by, say, a pen recorder or an oscilloscope, represent the variations with x of $y_1, y_2, \ldots . y_n$ for the real system. It will be noted that the solution of these equations involves, generally, the mathematical operations of addition, subtraction, multiplication, division, integration and, perhaps, the formation of functions, either analytic or arbitrary, of one or more of the variables. Electronic devices exist for performing all these operations on voltages, although in this article, only the most immediately important will be discussed.

Operational amplifier

The fundamental item of the electronic analogue computer is the direct-coupled operational amplifier, D-C amplifier, which should not be confused with the abbreviation d.c. for direct current: units of this type produce and operate on the voltages in the circuits of the equipment. They are electronic amplifiers, with valves or transistors, and can be likened in some respects to that in a gramophone or radio. If an electrical signal voltage is applied at the input end, a greatly amplified version of that signal is produced at the output end. An essential difference between the D-C amplifier and the gramophone amplifier is illustrated in Fig. 1. In (a) and (b) a signal oscillating about a mean level of zero is reproduced as a similar signal, also oscillating about a zero level, by both types of amplifier. In (c) and (d) a different situation is shown: the input voltages are both oscillating about a positive mean value, that is, the input signals have a direct current, or d.c. component. The gramophone amplifier rejects this d.c. component, and still gives an output that oscillates about the zero level. A direct-coupled amplifier, however, reproduces faithfully all features of the input signal, including the d.c. component. Although

this comparison is an over-simplification, it is sufficient for the purposes of this article. By an accident of nomenclature, a useful mnemonic can be evolved: a direct-coupled amplifier preserves the direct current component.

Feedback

As applied to the D-C amplifier, feedback consists of taking part of the amplifier output, or some modified form of the output, and impressing it on the input, thus changing the overall behaviour of the amplifier.

Resistor feedback. In Fig. 2, a D-C amplifier is represented by a box with an input voltage E_i and an output voltage E_o, and with one input terminal and one output terminal connected to earth. If a resistor of R_1 ohms is fitted in the live input lead, and another resistor of R_2 ohms is connected between the two live terminals, then the output voltage will be, to a good approximation

$E_o = -(R_2/R_1)E_i$

Therefore, if the two resistors are of equal value, at, say, 10,000 ohms, the output voltage will be equal in magnitude, but opposite in sign, to the input voltage. Alternatively, if $R_1 = 100{,}000$ ohms and $R_2 = 10{,}000$ ohms, then $E_o = -E_i/10$, that is, the output voltage is opposite in sign and one tenth as large as the input signal. The resistor R_2 is called the *feedback resistor.* Were it not fitted, the output might be —ideally and within the capabilities of the amplifier—several million times the input. If two input voltages A and B are applied through resistors, the values of which are equal both to each other and to the feedback resistor, the output voltage is equal to $-(A+B)$, Fig. 3. By increasing the number of inputs, a D-C amplifier may be used to add together a number of voltages, and no matter how the input voltages may vary with time, the output will always be equal to the instantaneous sum of the inputs.

Capacitor feedback. If the feedback resistor is replaced by a capacitor, or condenser, of, say, C farads the behaviour of the amplifier is even more radically altered. The output is then simply related to the total amount of the signal applied to the input. So, if the input signal is initially zero and then varying, as shown in Fig. 4, the output voltage 3 sec after the signal was first applied will be $1/R_1C$ times the area shown shaded. Mathematically, this operation is known as integration, and the output voltage can be expressed as

$$E_o = -\frac{1}{R_1C}\int_0^t E_i \, dt$$

An amplifier used in this way is known as an *integrating amplifier,* or an *integrator.* As with the earlier case of resistor feedback, several inputs can be applied simultaneously to an integrating amplifier, and then the output is $1/R_1C$ times the total signal applied to all the inputs: this arrangement is illustrated diagrammatically in Fig. 5.

Potentiometer

By selecting suitable values for R_1 and R_2 on a particular amplifier, it can be arranged that the output is some constant multiple of the input voltage. However, to use this method for making all multiplications by constant coefficients would involve carrying a very large stock of resistors of various values. Moreover, to change a multiplication factor in this way would be an inconvenient operation. Accordingly, it is usual to provide, in a complete general purpose computer, fixed resistors to give only a restricted number of factors—frequently 1 and 10—while, to give more general factors it is customary to use components that are called potentiometers, or potential dividers.

These are precision forms of a radio volume control: they consist of a resistor, across the ends of which a voltage is applied, and a wiper to contact the surface of the resistor and pick off the voltage at the appropriate point on it. From Fig. 6, it can be seen that if 100 V is applied to the upper end of the potentiometer, the lower end earthed, and the control knob set to a reading of 0·635, the voltage at the wiper will be 63·5 V above that of the earth. Consider the

Fig. 1. Typical characteristics of D-C and gramophone amplifiers

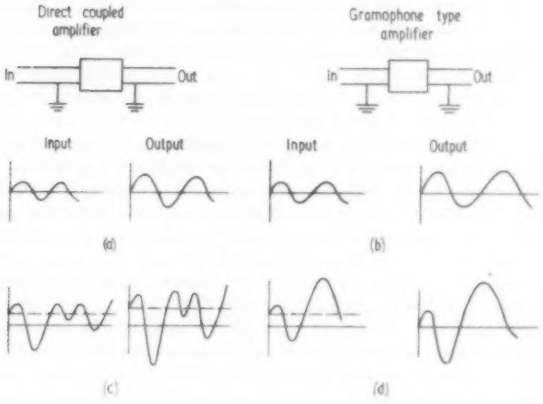


Fig. 2. Circuit diagram for D-C amplifier with resistor feedback

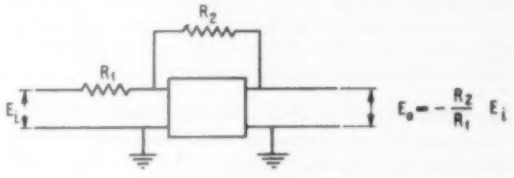


Fig. 3. A summing D-C amplifier with all the resistances equal

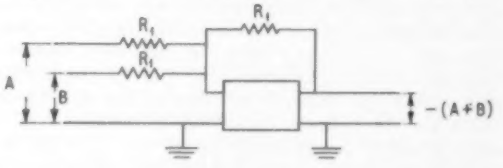


Fig. 4. Integrating D-C amplifier and a voltage-time diagram

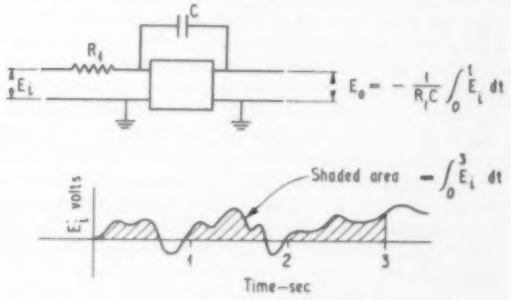
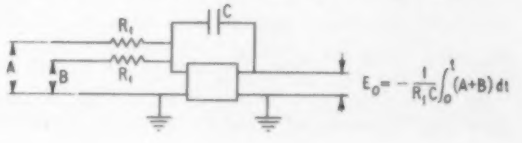


Fig. 5. The circuit of a summing integrator with two inputs



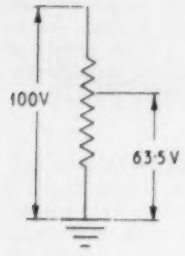


Fig. 6. A coefficient potentiometer set to a reading of 0·635, to give, for example, an output of 63·5 V from an input of 100 V

Fig. 7. Below: Arrangement of a potentiometer, set as in Fig. 6, and an amplifier to multiply E_i by the constant coefficient 6·35

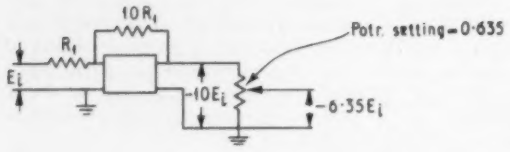
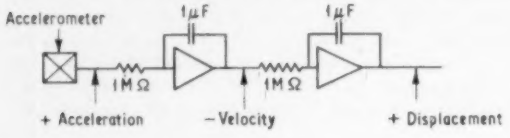


Fig. 8. Below: The computation of velocity and displacement



arrangement of Fig. 7: the amplifier output is 10 times the input, so the voltage at the wiper of the potentiometer is 6·35 times the input voltage and follows faithfully any variations in the input to the amplifier.

An application of a D-C amplifier system

Suppose, for the testing of a car suspension system, it is desired to measure the rise and fall of the chassis ends and of the seat, and the pitching angles of the car while running on the road. This can easily be done using integrating and summing amplifiers, potentiometers, and two accelerometers. The accelerometers are securely fastened to the front and rear ends of the car chassis, so that their output is an electrical voltage proportional to the vertical acceleration they experience. Now, if we integrate the acceleration of a point, the result is the instantaneous velocity of the point, while a further integration of the velocity gives the distance through which the point has moved. Therefore, if the output of an accelerometer is fed into a sequence or cascade of two integrating amplifiers, the output of the first amplifier gives the velocity of the accelerometer—and therefore of that part of the chassis—and the output of second amplifier gives the displacement of the accelerometer from the static position. In Fig. 8, the amplifiers are shown in the more conventional manner, as triangles, with the input at the base, output at the apex, and the earthed leads omitted, only the live leads being shown.

Now consider the vehicle sketched in Fig. 9: A and B are the two accelerometers, and C marks the driving seat. Let x denote the displacement of A above the static position, y the displacement of B, z the displacement of C, and θ the angle of pitch, in degrees.

Then $z = y\frac{a}{a+b} + x\frac{b}{a+b}$

and, for small angles of pitch, <10 deg,

$$\theta = 57{\cdot}3\frac{x-y}{a+b}$$

Suppose $a = 60$ in and $b = 90$ in,

Then $z = 0{\cdot}4y + 0{\cdot}6x$, and $\theta = 0{\cdot}382(x-y)$

An arrangement such as that of Fig. 10 can be used to solve these equations for z and θ. The four arrowed leads, marked x, y, z and θ carry voltages that are the analogues of these three linear displacements and the pitching angle of the actual vehicle. They can be recorded by, for example, an oscilloscope-camera system or a four-channel pen recorder. Employed in the complete system are the 2 accelerometers, 7 amplifiers, 3 potentiometers, the recorder and power supplies. By using transistor amplifiers, the whole equipment could be quite small and easily portable. The only work to be done on the test car is the fixing of the two small accelerometers; and to adapt the equipment to a different car involves no more than turning each of the three potentiometers to the appropriate new reading. Slight modifications to the scheme of Fig. 10 would permit measurement of the acceleration and velocity of the seat, instead of only its displacement. Both rolling and pitching motions could be measured by using four accelerometers, one at each corner, with appropriately connected amplifiers. Thus, objective assessment of overall suspension behaviour can be made easily with a small amount of special instrumentation, and with almost no work to be done on the car itself; moreover, the equipment can be adapted in a few seconds to suit any car.

Suspension design

Analogue techniques can be used not only to assess the characteristics of an existing suspension, but also to design and evaluate suspension systems before the vehicle is actually built. Consider the simplest form of suspension unit, Fig. 11. This consists of a mass—the wheel, tyre, brake, etc.—suspended on a spring and damper, which are anchored at their upper ends to the car chassis. For the preliminary analysis, this problem will be treated as though the car chassis were jacked up, with the wheel assembly hanging on the suspension system, and it is assumed that the wheel is forced upwards and then released, always remaining clear of the ground. Although this case is of little practical importance, it is conveniently simple for illustrating the application of analogue computers to mass-spring-damper problems. The extension of this conception to cases of real practical interest, with the four wheels in contact with the ground, and a car chassis and body supported on the four suspension systems is fairly straightforward.

For this preliminary case, it is assumed that the spring produces a force, both in tension and compression, proportional to the deflection from its unloaded length, and that the damper produces a force proportional to the speed of, and tending to oppose, the motion. When the system is at rest, the spring will be slightly extended from its unloaded state, and will be giving a tension force equal to the weight of the wheel and hub assembly. Let x denote upwards displacement of the wheel from the static position, then this is equal to the integral of $\dot{x}$, the upwards velocity of the wheel, which in turn is equal to the integral of $\ddot{x}$, the upwards acceleration of the wheel. If P is the difference between the force in the spring in the condition under examination and the static condition, then $P = kx$, where k is the spring rate, lb-ft. The force in the damper is $Q = c\dot{x}$,

Fig. 9. Arrangement of accelerometers for the determination of the rise and fall of the ends of a chassis and of the seat C

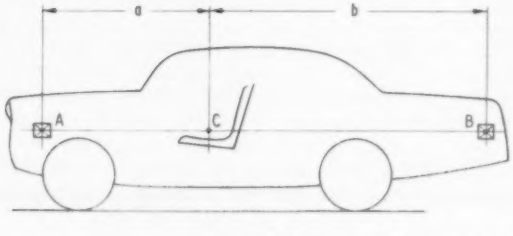
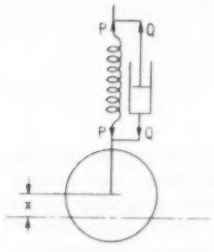
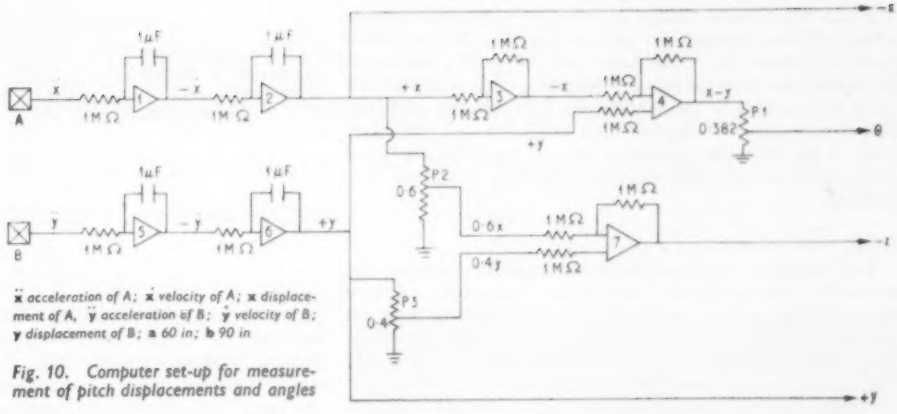


Fig. 11. Below, diagrammatic arrangement of the essential components of a simple suspension spring, mass and damper system





$\ddot{x}$ *acceleration of A;* $\dot{x}$ *velocity of A;* x *displacement of A,* $\ddot{y}$ *acceleration of B;* $\dot{y}$ *velocity of B;* y *displacement of B;* a *60 in;* b *90 in*

Fig. 10. Computer set-up for measurement of pitch displacements and angles

where c is the damping constant of the damper, in lb-sec/ft, which is assumed to be a simple viscous dash-pot type. Then, if w lb is the weight of the complete wheel assembly, the equation of motion is

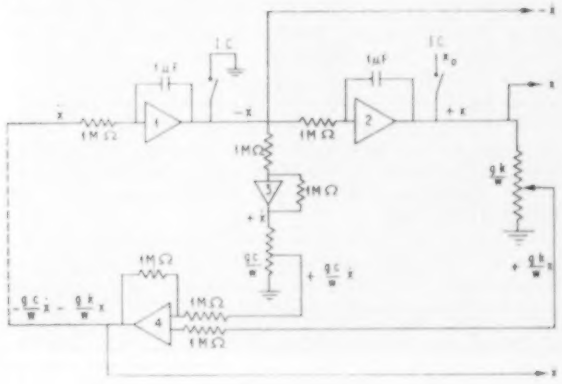
$$\frac{w}{g}\ddot{x} = -(P+Q) = -kx - c\dot{x}$$

and $$\ddot{x} = -\frac{gk}{w}x - \frac{gc}{w}\dot{x}$$

Now, assume that a voltage representing the wheel acceleration $\ddot{x}$ ft/sec^2 is applied as input to amplifier 1, Fig. 12. Then the output of this amplifier will be $-\dot{x}$, that is, the wheel velocity, but with a minus sign. Using this as input to amplifier 2 will give an output equal to $+x$, which is the analogue of the wheel displacement. Passing this through a potentiometer set to the value gk/w produces, on the wiper, a voltage of gkx/w. In the same way, if the output $-\dot{x}$ of amplifier 1 is passed through amplifier 3, which serves only to change the sign to $+\dot{x}$, and then through a potentiometer set to gc/w, the wiper voltage is $gc\dot{x}/w$. These two voltages can then be added, in amplifier 4, to give an output of $-gc\dot{x}/w - gkx/w$. But the equation states that this is equal to $\ddot{x}$, the wheel acceleration. It follows that, assuming that the input to amplifier 1 is equal to $\ddot{x}$, the output from amplifier 4 is also equal to $\ddot{x}$; so the output from 4 can be used as the input to 1, as shown by the dotted line.

Now, if the system of Fig. 12 is connected up in this way, the voltages at all points will remain zero, representing the static condition. However, by adding the two switches marked I.C. (Initial Conditions) the system can be used for useful calculation. For example, in regard to the actual suspension system, supposing that it is desired to study the case where the wheel is forced upwards through a distance x_o, held stationary for a moment, and then released: if the two I.C. switches are closed, and the line carrying $-\dot{x}$ is earthed to zero voltage, representing the wheel held stationary, while the line carrying x is connected to a source of constant voltage equal to x_o, in the chosen scale of volts in the computer to represent feet of wheel movement, then all voltages in the circuit will be analogues of the corresponding quantities in the suspension while it is held in the deflected state. If now the I.C. switches are opened, the voltages at the points where they are connected are immediately free to vary: so, as the voltages in the circuit readjust themselves, they will behave in exactly the same way as the corresponding quantities in the actual suspension system. It follows that, by connecting the arrowed leads on the right to separate channels of an oscilloscope or pen recorder, traces can be produced which are, to the appropriate scale, graphs of the variation with time of the wheel acceleration, velocity and displacement. Also, kx is the spring force

Fig. 12. Below: Computer set-up for the representation of Fig. 11



relative to the static condition, $c\dot{x}$ is the damper force and $w\ddot{x}/g$ is the total force applied to the axle and the chassis at the suspension anchorage.

Variations in wheel weight w, spring stiffness k and damper constant c can be made simply by setting different values on the two potentiometers. This scheme can be further developed by using additional electronic devices, introducing other features such as variable rate springs, backlash, bump stops, and dampers with laws other than a simple linear law or which work in one direction only. By using four systems, one to simulate each suspension, with suitable interconnections, predictions can be made of the behaviour of a complete car and its suspension system when travelling along a road with a prescribed set of bumps. The input disturbances can range from the simplest case, of a single bump or ramp generated within the computer, to, for example, a tape recording representing an actual road surface. It is, of course, necessary to ensure that the rear wheels encounter a given bump a certain time after the front wheels have done so, the time interval depending on the wheelbase and speed. This can easily be arranged in the computer.

Clearly, it should be possible to design the optimum suspension for any combination of car, load and road, before a single component is made. This would seem to offer considerable advantages over the more usual techniques. For example, by turning a few knobs on an arbitrary function generator, a designer could see in a few seconds the effect of a damper characteristic which is so far removed from normal that he would never dream of wasting time making one for experimental purposes, yet which might be found to give just the effect he is looking for to meet requirements.

It has been found simple to simulate a damper characteristic of, for example, the type in Fig. 13. This is taken from the papers by McWilliams and Maxwell[1], and other examples have been given by Hoffman[2]. One would hardly make up a couple of special dampers to a guessed specification, which may be useless when tried, but, on the other hand, if the analogue computer were to show them to have advantages over simpler types, the position would be very different.

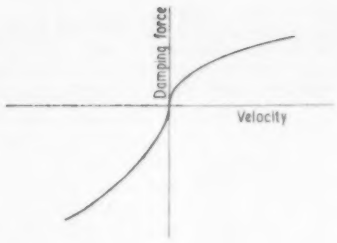


Fig. 13. It is not difficult to simulate a damper characteristic such as that illustrated here

Other applications

The foregoing has shown how the analogue computer can be used for the design and study of one component assembly of a vehicle, but the use of the computer is by no means limited to the solution of suspension problems. It seems likely that crankshaft torsion, torsional damping, manifold design, structural distortion and many other problems directly relevant to vehicle design could be tackled with an analogue computer.

There is also scope outside the direct field of vehicle design. A computer could be used to study the performance of a proposed production line and indeed to simulate a complete factory. Special purpose computers can be used to control the operation of a complete production line or of a single machine tool. In many applications the time-scaling facility is of great value: this facility is that for speeding or slowing processes so that each second on the computer can represent, for example, one thousandth of a second of gas flow in an inlet manifold, or six months of factory operation. Traffic engineering is another obvious application for analogue computers.

There is a very wide range of computers available today: some are indigenous products and others are imported or made under licence, usually from America. They range from small 5-amplifier designs, intended mainly for training and teaching but capable of solving simple problems, up through the popular range, with about 30 amplifiers and costing from £7,000 to about £12,000, the price depending partly on the amount of other equipment included in addition to the basic D-C amplifiers. Larger machines are also available with several hundred amplifiers, while one British company is preparing one with 1,500 amplifiers.

One of the most impressive forms of analogue computer is the flight simulator. This is set up to duplicate the characteristics of a complete aeroplane and can then be virtually flown by a pilot. It may be used either to assess a proposed control system for a project design, or to train pilots to fly an existing type of aeroplane. In the latter function, the simulator is so realistic that time spent training on it is credited, in part, towards the experience demanded of a pilot before flying the type in actual airline service.

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Thickness Testing of Plating

AS IS widely known, considerable interest has been taken by the British Non-Ferrous Metals Research Association in methods of improving the life of chromium plated items. One project in this connection has been the designing of an apparatus for the accurate measurement of plating thickness. The association's design has recently been adopted for manufacture by Nash and Thompson Ltd, Hook Rise, Tolworth, Surrey, and the production version is known as the B.N.F. Coulometric Thickness Meter. This equipment is equally suitable for tests in the research laboratory or the inspection department, and can be used by unskilled staff.

The principle of operation of the meter is simple: it integrates the time and the current density needed to strip the plating from a standard area of the specimen. This stripping is effected by means of a chemical solution, through which an electric current is passed; the composition of the solution varies with the type of plating and the base metal. The operation normally takes only a few minutes, and the meter is switched off automatically when the stripping action is completed. According to the manufacturers, the meter can be used to measure the plating thickness of any of the following combinations: chromium on nickel; nickel on steel, brass or copper; copper on steel or zinc; cadmium on steel; zinc on steel; and nickel on aluminium.

On the meter is a pivoted arm carrying a cell, which is placed on the plated surface under test. A quantity of the stripping solution is placed in the cell, and the potential is set to the appropriate voltage. When the starting control is switched on, the test then proceeds automatically. After the meter has switched itself off, the thickness of the plating can be quickly calculated by multiplying the dial readings of the time and current density integrators by a factor depending on the nature of the plating. An accuracy of ±5 per cent is claimed over a thickness range from 0·000004 in to 0·0015 in, which should cover all normal plating shop and laboratory requirements.

The B.N.F. Coulometric Thickness Meter is operated by a 240 volt, 50 cycle mains electricity supply. Its ready portability can be assessed from its overall dimensions of $9\frac{1}{2} \times 6 \times 8\frac{3}{4}$ in and its weight of about 16 lb. Supplied with each meter is an instruction book and a spare cell cap.

Transducer Exhibition

ENGINEERS who are interested in the application of electronic computers to their problems may obtain some useful information from an exhibition to be held from 16th to 20th January, in London. The exhibition, which will be open from 10 a.m. to 7 p.m. daily, admission free, is being organized by S.E. Laboratories Ltd, of Feltham, Middlesex, and will be held at Grosvenor Hotel, Buckingham Palace Road, S.W.1. Refreshments will be available and transport provided to and from the Physical Society Exhibition, also open then. Among the products on show will be the following: automatic data recording equipment; flow control equipment; a number of new pressure transducers; position transducers and accelerometers; fully transistorized carrier amplifier equipment; linear integrating and multi-channel integrating equipment; multi-channel oscillators and demodulators; U.V. recorders, with 50 and 25 channels, for use with 6 in or 12 in paper; a range of flowmeters from $\frac{1}{4}$ in to 5 in; and digital control equipment for various applications.

Precision Sizing of Holes

Method That Does Not Require Skilled Labour and is Readily Applicable to Modern Automatic Production Techniques

A PROCESS termed "Ballizing", for finishing and sizing holes, has been developed by the Ball Division of Industrial Tectonics Inc, Ann Arbor, Michigan, U.S.A. It does not involve the removal of metal: instead, the bore is burnished, by forcing a very hard ball through it, and this has the advantage of refining the surface structure and leaving a layer of denser metal round the hole. A wide range of balls of tungsten carbide and hardened chromium alloy steels for this purpose is offered by this manufacturer.

The standard of surface finish imparted to the bore is said to approach that of the ball. Materials best suited to the Ballizing process, listed in order of merit, are: sintered iron, sintered brass and other soft metals; aluminium, brass and bronze; mild steel, screw stock; high carbon and alloy steels; stainless steels and other nickel alloys. Ballizing of case-hardened parts is practicable where the case depth is no more than 0·015 in and the core is thick in proportion; in this application the hole may be Ballized both before and after hardening, if desired.

Apart from the extreme rapidity of this process, there are other advantages. There need be no down-time, since balls can be inspected and, if necessary, replaced without production being interrupted; accuracy is determined solely by that of the dimensions of the ball; because of the extremely hard-wearing surface of the balls, a long service life is obtained; tool replacement costs are low; surface finish is of a high order; unskilled labour can be used in virtually all applications; the process is adaptable to automated systems; and, the manufacturers claim, the need for selective fitting of mated parts is obviated because of the closeness of the dimensional tolerances obtainable. Curved tubing, if completely retained in a fixture, can be treated by using a sizing ball and a series of smaller pusher balls.

Selection of the correct size of ball for a given application depends on many factors, and for this reason no formula for pre-determining the size has yet been developed. The experimental approach has been found to be virtually the only way of arriving at the desired hole size, and this work is undertaken by Industrial Tectonics Ltd, through the agency of their representatives in Britain, Insley Industrial Supply Co. Ltd, 21/22 Poland Street, London W.1. The ball size appropriate, and the characteristics of the finished hole, depend on the following factors:

1. Type of material to be worked
2. Hardness and work-hardening characteristics of the material
3. Record of cold working and heat treatment of the workpiece
4. Ductility of the material
5. Out of roundness of unfinished hole
6. Tolerance of the unfinished hole
7. Surface roughness of the unfinished hole
8. Thickness of surrounding metal
9. Method of supporting workpiece
10. Lubricant used

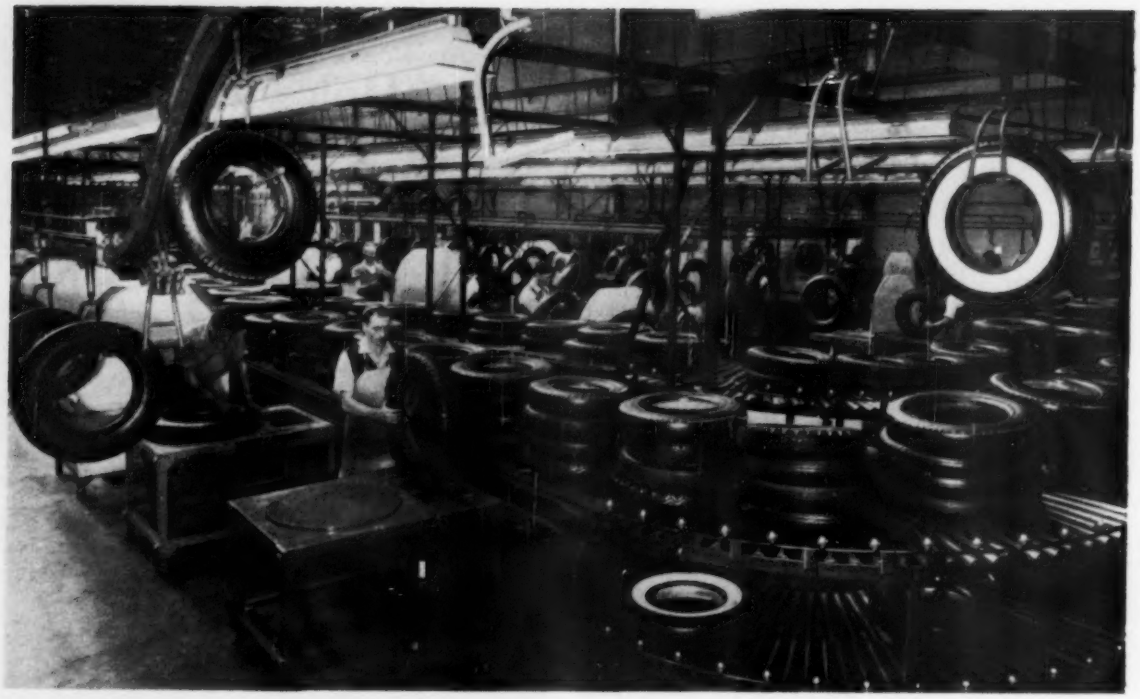
Where a ball of standard size is found unsuitable for a given application, the manufacturers are able to supply variants within increments of 0·0001 in diameter, and these

A thin wall tube being Ballized on a hydraulic press. The workpiece is fully supported by the fixture so that bell mouthing is obviated

can be produced in any quantity, to suit either batch or volume production. Tungsten carbide balls are used in most applications, but hardened chromium alloy steel balls can be employed where production quantities are small or the workpiece is of relatively soft metal.

Ballizing is used successfully in holes ranging from 0·020 in to 5 in diameter, although best results are generally obtained in the range $\frac{1}{16}$ in to 1 in diameter. The length of the hole should not be less than $\frac{1}{20}$ nor greater than 10 times its diameter, and wall thickness should be greater than $\frac{1}{10}$ of the hole diameter. Materials harder than 40-45 Rockwell C may not be greatly improved in surface finish. In most cases, the force required to press a ball through holes less than 3 in diameter does not exceed 2 tons, but its actual value will depend on length of hole, diameter, amount of interference fit between hole and ball, compatibility of hole material with ball, elasticity of material, and lubricant used. A lubricant is recommended, unless phosphating or plating has preceded Ballizing. In some instances the cutting oil from the previous operation will suffice; in others, some experiment will be needed to determine the most suitable lubricant.

Typical examples of parts the bores of which can be successfully Ballized are: gear blanks, pulleys, collars, spacers, bushes, sleeves, tubing, and holes in stampings and die castings can also be treated. The desired results may not always be obtainable in holes that have surfaces interrupted by such features as cotter holes or oilways, but holes that are broken into by diametral drillings whose diameter is less than $\frac{1}{4}$ of the ball diameter can be Ballized.



View of the U-shape main conveyor, on which all the incoming tyres are stacked, and from which they are removed for the visual examination

Non-Destructive Tyre Testing

The Dunlop Central Inspection Department for Quality Control in Car Tyre Manufacture

AT the Fort Dunlop tyre factory, the Dunlop Rubber Co. Ltd. operates a Central Inspection Department for quality control of car tyres. The activities of this new department supplement, but do not in any way supersede, the previously existing inspection and test routines, which include checks at all stages of manufacture together with the testing to destruction of sample products, both on laboratory machines and on the road. In view of the obvious thoroughness of this system, it might well be asked why an additional facility was thought to be necessary. The answer is simply that the company appreciated the desirability of still closer quality control than was already provided.

Tyres play such a vital part in the safety of a road vehicle that, it was decided, the ultimate responsibility for the maintenance of the essential high quality should be taken out of the hands of the production departments and given to an independent branch of the organization. The Central Inspection Department is the outcome of that decision. So that it shall be free from any pressure that might otherwise be brought to bear by the production departments, the C.I.D. is entirely separate from the rest of the factory, both physically and in terms of its administration. It operates continuously throughout the working week, each day being divided into three eight-hour shifts. On each shift, the department is staffed by about 20 inspectors, and its present output is about 100,000 car tyres every week. These inspectors, who are specially trained for the job, are paid at day-work rates, to obviate the tendency towards hurried work that might occur if piece-work rates were applied.

Although a large number of the inspection operations are visual, or involve the use of the sense of touch or feel, several specialized testing machines are installed in the department. Most of these have been designed by Dunlop engineers, and some of them apply tests of a completely new type. All car tyres pass through a common basic inspection routine, but extra tests are applied to certain categories.

Layout of the department

One conveyor system is employed for the delivery of the tyres to the inspectors, another for taking away those that have been passed, and a third for removing rejects. The tyres are delivered from the factory in trailers, each of which holds 500 or 600 units, depending on their size. In the unloading bay, which is at one end of the shop, they are transferred to a gravity conveyor. The tyres are moved by hand from the delivery end of this conveyor to another at approximately waist level, a height that facilitates subsequent handling. This second conveyor is horizontal and is of the combined belt and roller layout. As viewed in plan, the arrangement is of U form, doubling back on itself so that there are two U sections of track, one inside the other, to form an endless conveyor circuit. The junction between the inner section and the outer one, at the end of each arm of the U, is a semi-circular portion of roller track. Inspection benches are ranged along both arms of the conveyor.

The tyres are stacked in piles of four on the outer track, to travel round the circuit, and are taken off one at a time by the inspectors, who carry out the routine check. Any

tyres not dealt with on their first lap are recirculated together with the incoming tyres from the factory. Accepted tyres are placed by the inspectors on another conveyor, running beneath the first one. Those that are rejected are marked to indicate the position of the fault and are then placed on an overhead monorail conveyor, which transports them to the grading section where their future is decided. Further reference to this section will be made at a later stage.

Covers that have been passed by the inspectors are transferred by hand from the lower conveyor to one or other of two horizontal roller conveyors. The latter, in effect, form extensions of the arms of the double U system. Tyres that have to undergo special tests are removed for that purpose from these conveyors.

On completion of the tests they are replaced and are pushed with the other tyres towards the despatch end of the shop, which is the end remote from the base of the U. On reaching the ends of the conveyors, all the tyres are taken off and subjected to a venting operation, which will be described later. From the venting machines, the tyres are transported by a further conveyor to the checking-out point, and thence by small electric trucks to the adjoining store.

The left-hand tyre is being rotated under a contour gauge, while an inspector examines the nine casing vents of the second cover

Details of the procedure

Every tyre is given a thorough visual and manual inspection on the bench. To obviate, so far as practicable, the possibility of any defect being missed, only very experienced inspectors are engaged on this check, and they work to a rigid routine. For facilitating the inspection operations, each bench is fitted with a horizontal turntable and a pair of rollers; the tyre can be revolved while lying on either side on the turntable, and it can be rotated in the vertical plane on the rollers. Checks on the inside of the casing, the beads, and the side-walls and tread are all included in the routine of the inspection, and the chance of a defect being unnoticed is extremely remote.

Slight irregularities in the contour of a tyre do not affect its general performance. However, they form a possible source of running noise, and so are undesirable in those intended for exceptionally quiet cars. Since the presence of these irregularities cannot be detected in the basic inspection just outlined, the tyres for this type of application are checked on a machine. Each is fitted on a split-rim wheel carried on a fixed spindle, and is inflated to its normal pressure; it is then spun while a contour gauge is brought up close to the tread. This process reveals any variations in the radial dimensions, and a pointer on the gauge is aligned with the moulding flash round the middle of the tread to disclose any lateral irregularity.

Another possible source of noise is small variations of stiffness round the circumference of the cover. Variations of this kind can, of course, give rise to minor vibrations on smooth road surfaces, though again they are not harmful in respect of the general performance of the tyre. To ensure an adequate consistency of tyre stiffness, a special test machine has been designed and constructed by the Dunlop engineers.

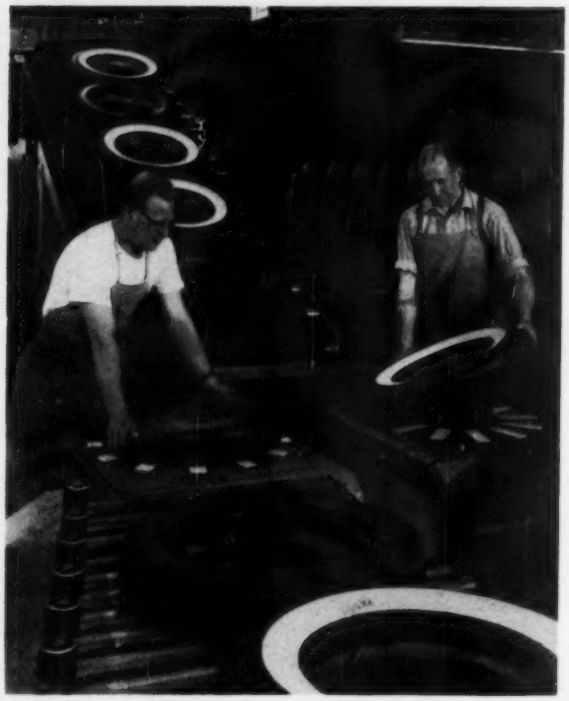
This stiffness testing machine also is equipped with a split-rim wheel, on which the tyre is mounted; since the tyre is not inflated, a spacer is employed to locate the beads firmly against the rim flanges. The wheel spindle is carried by a pivoted lever, on the free end of which are mounted weights appropriate to the type of tyre. These weights cause the tyre to be pressed against a steel drum, by which it is revolved at 260 r.p.m. The noise generated is picked up by a microphone mounted alongside the tyre and connected to a milliameter on the control panel. Only if the maximum reading on the instrument is below a specific figure, determined according to category, is the tyre accepted.

Another specialized machine is used to grade the Duraband

Above: The stiffness testing machine, in which the noise generated by the rotating tyre is picked up by a microphone. Below: Duraband rigid-breaker tyres are graded on this machine, which incorporates a system of strain gauges feeding signals to an electronic analyser

rigid-breaker type tyres. The construction of these tyres is unconventional, in that the warp of the fabric plies is set at 90 deg to the centre line of the tread, instead of at the usual oblique bias angle. Bands, or breakers, of bias-cut steel fabric are then fitted to the casing, and the tread is applied over them. In service, these steel breakers brace the tread, holding it firmly in contact with the road surface, and so give good control. However, the stability and other characteristics of Duraband tyres depend on the accurate positioning of the breakers in relation to the tread centreline. These various characteristics are evaluated by the grading machine.

Although full details of this machine have not yet been released, it can be stated that it consists basically of a test drum linked to an electronic analyser. The drum is balanced to fine limits and is, therefore, extremely sensitive to tyre irregularities. A system of strain gauges measures



Above: Though venting of the side wall is necessary only on tubeless tyres, all the covers passing through the C.I.D. are treated in this way, for simplicity of the organization. Tyres for rims between 13 and 16 in diameter are vented by these two semi-automatic machines

forces such as load, load range, mean steering pull, steering pull range, self-aligning torque and cornering force.

The tyre is mounted on a wheel attached to the machine and is inflated to 25 lb/in^2, after which it is applied to the drum under a predetermined load. It is then given 2½ revolutions in each direction, reversed on its wheel mounting and again rotated 2½ times in each direction. During the test sequence, electric signals are transmitted by the strain gauges to the analyser, which convert them electronically into dial readings. The test results determine whether a Duraband tyre shall be classified as suitable for fitting to front or rear wheels, or to rear wheels only.

Although the venting process mentioned earlier is necessary only on tubeless tyres, those of the tubed type are treated also, to simplify organization. It has been found that, in service, air tends to permeate through the inner lining into the casing of a tubeless tyre, so weakening the adhesion between the plies. This permeation can render a a tyre unsuitable for retreading — an obvious economic disadvantage for many motorists.

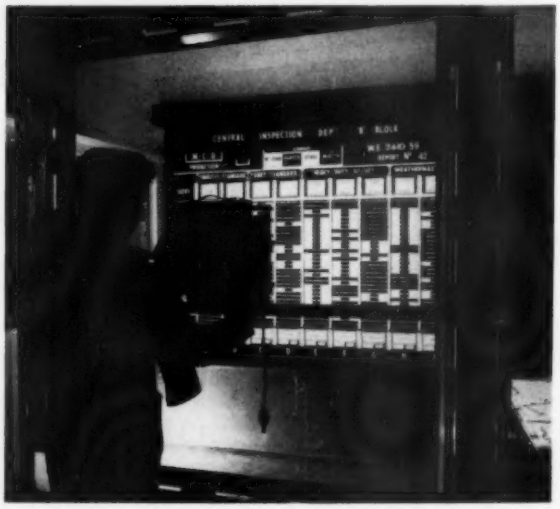
To obviate this possibility of ply separation, a method has been evolved of permitting the casing to breathe, or bleed, to the atmosphere. The venting is done by machine and consists of making a ring of nine small needle vents in one side wall, just above the fitting line; the vents penetrate as far as the second ply. For obvious reasons, the depth of penetration has to be carefully controlled.

Because of the range of tyre sizes and the constructional differences between one type and another, there are three venting machines. Two are identical and deal with tyres suitable for rims of between 13 in and 16 in diameter; products in this category, of course, constitute the bulk of the company's output for cars. The third, a smaller machine, takes the 10 in tyres for the B.M.C. ADO 15 vehicles. In each case, the operating principle is the same and the semi-automatic cycle time is only 3 sec. The tyre is placed on the horizontal table of the machine and the starting pedal is depressed. A ring of pneumatically operated jaws engages on the lower bead and pulls it firmly down on to the table. Then the needle holders are brought up, also by air pressure, until they contact the side wall. When contact is made, the needles emerge from their holders, pierce the tyre and are automatically retracted. As soon as the needle holders move clear of the tyre, the jaws release their grip, and the tyre can be removed.

If a rare defect, such as a broken bead wire, is suspected by an inspector, it can be investigated by means of X-ray equipment. Apparatus of this type has been used for many years in the Process Control Department for examining the internal structure of tyres, and several special techniques have been evolved for the purpose. It is of interest that the equipment is also used by the experimental engineers to study the structural changes that occur inside a tyre during service.

In addition to the routine inspection and testing described, the Central Inspection Department is responsible for a number of random checks. Among these checks are the measurement of size and weight, and also of static and dynamic balance. Any irregularity is at once reported to

Every defect revealed by the tests is reported to the administrative office. There the reports are analysed and recorded on the master chart seen in this illustration. The chart is photographed each hour and prints are circulated to the production departments concerned



the production department involved, and the check is made 100 per cent on all tyres of the same type and size until rectification is assured. Should it seem desirable to do so, the check is extended to the tyres that have already been passed to the stores.

Procedure for defective tyres

As has previously been stated, tyres that fail to satisfy the inspectors are transferred to the grading section, which is staffed by another team of highly skilled inspectors, under the control of a specially qualified foreman. Here they are carefully examined to determine the most satisfactory method of making them suitable for service. This examination of suspect tyres forms only a part of the graders' work. They are also responsible for initiating the reporting of rejects to the factory department concerned, so that action may be taken to avoid a repetition. The graders fill in a brief report form for every tyre they check, and these forms are at once passed to the administrative office. There the defects, which represent a very small proportion of total production, are analysed and recorded on a master chart, which is photographed every hour to obtain a permanent record.

In this way, trends become obvious at an early stage, not only to the Central Inspection Department but also to the production sections, to which prints of the chart photographs are sent as a matter of routine. As soon as it is clear that a particular defect is not an isolated occurrence, it is customary for the management of the C.I.D. to invite the appropriate factory executive to inspect and discuss the rejects, on the shop floor. By avoiding any possibility of misunderstanding, this system of personal contact greatly assists the formulation of the correct remedial action, with minimum loss of time.

De Normanville Overdrive

IT HAS been announced that, from the beginning of 1961, the British-designed de Normanville overdrive will be produced, under licence from Auto Transmissions Ltd, by the Edoardo Bianchi company of Milan. Initially, the Italian firm will make the D type de Normanville overdrive, for cars up to 2 litres capacity.

For some time, Ferrari have been fitting de Normanville overdrives to their 250 Gran Turismo and 400 Super America models. The establishment of manufacturing facilities in Italy will be especially valuable so far as the supply to Germany is concerned, since there is a lively interest in overdrives in that country. In fact, the new plant, capable of producing 100 units a day, will be well placed to meet the demands of all the Inner Six countries.

Auto Transmissions Ltd, of Coventry, are the designers and patentees of this overdrive, which is manufactured under their licence in the United Kingdom, and marketed under the name of Laycock-de Normanville, by Laycock Engineering Ltd, of Sheffield. The latter company is, of course, a member of the Birfield Group, whereas Auto Transmissions Ltd, which was inadvertently described in our Show Review Issue as a member of that group, is not.

Fatigue

STEEL subjected for a short period to extreme stresses reacts in a manner diametrically opposed to that of some light alloys. This discovery was announced by Dr. Hempel, of Germany, at a meeting of the Working Party on Fatigue Failure in Metals, organized by the European Productivity Agency of the O.E.E.C. This Working Party was set up because a series of failures — some causing accidents to certain airliners—revealed that too little was known about the nature and causes of fatigue in metals. It was decided that at least 5,000 samples must be tested to destruction, particular emphasis being laid on the effects of variations in the degree of stress applied. To attempt to carry out this work in a single laboratory, or even a single country, would take far too long, and this is therefore one of the instances where international co-operation, co-ordinated by a central organization, can be so useful. In fact, the tests are being carried out in nine European countries, the United States, and in Canada.

So far, some 500 samples have been used, chiefly with the idea of establishing whether the methods and the stresses agreed on in advance were suitable. They have proved to be so, and work is now about to begin on the main batch of 5,000 samples. They will be tested for varying periods at four different stresses, known for convenience as the S1, S2, S3 and S4 values. The value of S4, used by Dr. Hempel, was 70 kg/mm^2. Although these preliminary tests were not expected to yield any conclusive results, it rapidly became apparent that steel subjected to stress of this severity, for even a short time, subsequently cracked up very fast under much lower stresses, such as S1 or S2. The effect on various light alloys, however, was to harden and strengthen them, so that they subsequently stood up better to prolonged periods of moderate stress than they did when not subject to an initial period of high stress. Further information can be obtained from O.E.E.C. Information Division, Château de la Muette, 2 Rue André-Pascal, Paris 16.

Strip Oiler

AS AUTOMATION is applied increasingly to power press tools, so also does the need arise for thorough cleaning and lubrication of the strip before it is fed into these machines. Clark's Press Equipment Ltd, of West Drayton, Middlesex, has recently introduced an oiler for strip. The mechanism comprises a box, which contains freely rotating felt rollers, and individual needle valves control the amount of lubricant fed to the cores of the rollers. Rubber squeegees, mounted at the point of entry, clean the material as it passes into the box.

By virtue of the feeding of the lubricant to the centre of the roller, distribution as well as the amount of the oil supplied is controlled, and so there is less likelihood of excess lubricant dropping on to the floor or fouling the tools. The side of the lubricator can be opened, so loading the material is a simple operation. The equipment has also been used for other purposes, such as the application of degreasers or thinners, prior to follow-on operations on the strip. Attachment to the press bed or to an automatic feed unit is said by the manufacturers to be an easy matter.

Mechanical Vibrations

EARLY in the New Year, at the University of London, there will be a series of special lectures on aspects of mechanical vibrations, by Prof. J. P. den Hartog, Ph.D. These lectures will be given in the Anatomy Theatre at the University College, Gower Street, London, W.C.1. The first will be at 5.30 p.m. on 30th January and the second and third lectures will be at the same time on 1st and 2nd February, 1961. Lecture I is entitled "Torsional Vibrations in Engine Systems, Caused by Gear Inaccuracies"; Lecture II is "Random Vibrations"; and Lecture III is "Non-Linear Systems". Admission is free and tickets are not required.

Piezoelectric Ignition System

Self-Contained, Mechanically Actuated Unit of Compact Dimensions and Light Weight

MOST engineers are familiar with the phenomenon of piezoelectricity—the property of certain crystalline materials to generate an electric charge when compressed. Conversely, these materials undergo dimensional changes when subjected to an electric field. The most commonly encountered applications of the direct piezoelectric effect are in microphones, gramophone pick-ups and accelerometers, whereas the converse effect is employed in industrial ultrasonic transducers. Several interesting new developments have recently taken place in this field, some of them germane to automobile engineering. Among these, the most noteworthy is probably the so-called spark pump, a self-contained ignition unit for petrol engines of the two-stroke or four-stroke type, having one or two cylinders.

The success of this and other present-day applications of piezoelectricity is largely due to the good properties and performance of the latest polycrystalline materials, which have largely superseded the single crystals of quartz, Rochelle salt, lithium sulphate or ammonium dihydrogen phosphate formerly used. It is, perhaps, necessary to explain that, in these polycrystalline materials, the piezoelectric effect is attributable to a characteristic known as ferroelectricity, because of its analogy to that exhibited by permanent magnet materials. When a strong electrical field is applied, the naturally distributed polarities of the various crystalline centres are reorientated, and align themselves with the applied field. This new orientation is retained after the field is removed.

One of the first piezoelectric ceramics to come into use was barium titanate, but a more recent and more satisfactory material is lead zirconate-titanate. This is a solid solution and is superior to barium titanate in having lower dielectric losses, a reduced rate of depolarization, and the ability to operate at substantially higher temperatures. To enhance the stability, certain other chemicals are added to the lead zirconate-titanate; the additives, which do not enter the solid solution, have a markedly beneficial effect on the mechanical and ageing properties, and on the dielectric constant. These modified lead-base ceramics are employed in the PZT range of pressure-moulded products manufactured in the U.S.A. by the Clevite Corporation, and in Britain by its associated company, Brush Crystal Co. Ltd, of Hythe, Southampton.

The spark pump referred to in the first paragraph is, in fact, made by Clevite and is fitted to a Clinton industrial engine, produced in the U.S.A. and imported by Lambretta Trojan Ltd. This engine, designated VS-3100 Gem, is a single-cylinder side-valve unit, with a swept volume of 8·3 in^3, the design of which is largely orthodox. It is stated to produce 3·25 b.h.p. at 3,600 r.p.m. and its maximum torque of just over 5·4 lb-ft is obtained at 2,500 r.p.m.

As can be seen from the accompanying illustrations, the spark pump is very compact. It occupies a volume of 3½ in^3 and its weight is only 8 oz. A simpler ignition unit would be difficult to imagine: the basic unit comprises merely the piezoelectric element and a lever system for applying the compressive load. The element consists of two PZT ceramic rods, each ¾ in long × ⅜ in diameter, which are a sliding fit in a hole in a moulded plastics housing. These rods have silvered ends and are separated by a steel disc $\frac{1}{16}$ in thick, on each side of which is a 0·002 in thick coating of conductive rubber.

A similar disc is interposed between the outer end of each rod and a thrust pad that protrudes through the container. One of these pads forms the fixed abutment of the element, though it is in fact adjustable in an axial direction by means of an externally mounted screw. The other pad has a hemispherical outer end, which is acted on by the lever system.

Midway between the ends of the housing is the high-tension pick-up. It is positioned radially in the same plane as the steel disc separating the rods but does not touch it: the current jumps the small gap between the edge of the disc and the pick-up. Since the outer ends of the element are earthed, it is apparent that the rods are arranged in parallel. It has been found preferable to use this layout of two rods, rather than one thicker rod of equivalent electrical properties, owing to the physical considerations involved. The greater the diameter of the element, the more difficult it becomes to distribute the compressive load uniformly over the end face: failure to load the rod uniformly could result in shattering of the ceramic. In this connection, the function of the coating of conductive rubber on the discs is to ensure the necessary uniformity of loading by filling surface imperfections on the ends of the rods and thrust pads.

The moulding that houses the rods is secured to the base

This view of the Clinton industrial engine, which is designed to run with the crankshaft axis vertical, shows the neat installation of the spark pump, between the side of the crankcase and the cooling fan

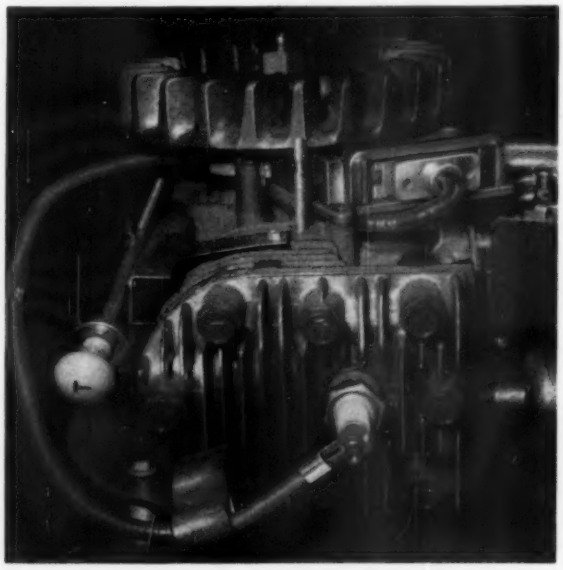


plate of the spark pump by means of a steel holder, which also carries the adjusting screw mentioned earlier. On the base plate are mounted the two pivots of the compound lever system. The use of two levers, rather than one, results in a compact layout and provides adequate robustness for the overall leverage of 15 : 1. On the first lever, which is actuated by a cam, is a projection that bears on the end of the second lever. In the case of the four-stroke application under review, the cam is on the valve gear camshaft, but on a two-stroke engine it would obviously be on the crankshaft.

A compressive load of 80 lb is applied by the second lever to the piezoelectric element. This thrust generates a voltage of 21,000, which is ample for normal ignition requirements. The element could produce up to 30,000 volts but, in the interest of reliability, the limit has been set well below this figure to hold the operating stresses to a reasonable level. In fact, the maximum stress is in the region of 7,000 lb/in^2.

Electrically there is no reason why the actuating cam should not be used also as the timing cam. This would clearly be the simplest possible arrangement, but it would necessitate a highly accurate cam form and relatively rapid acceleration in order that the point of initial lift should be clearly defined. High rates of acceleration would, of course, increase the loading on the element. Therefore, the actuating cam is merely an eccentric, and use is made of the high capacitance of the PZT material to store the charge until it is needed. The circuit is completed at the appropriate instant by a simple adjustable timing switch—camshaft operated in this instance. This switch is inserted in the circuit between the pick-up and the lead to the sparking plug.

It may not be realized, perhaps, that the complete piezoelectric cycle involves the generation of two electrical charges, one on compression of the element and the other, of the opposite polarity, on its release. On a single-cylinder engine the second charge is bled to earth by means of the timing switch, but use can be made of this feature on a twin-cylinder unit, since it enables both plugs to be fired by a single spark pump. In this case, the timing switch becomes an elementary form of distributor.

Since the magnitude of the piezoelectric charge is proportional to the applied stress, the voltage is virtually independent of the rate of compression of the element. It follows that a powerful spark is obtained even at very low cranking speeds, which of course is beneficial so far as starting is concerned. At the other end of the speed scale, the voltage build-up is so rapid that efficient operation should be obtainable even at speeds as high as 10,000 c/min. A secondary benefit obtained by virtue of this rapid build-up of voltage is that sparking will occur at the electrodes of a plug that is too fouled to be usable with an orthodox ignition system. It is worthy of mention that the PZT ceramic material has a high efficiency of energy conversion, the output being up to 80 per cent of the input.

Any piezoelectric material tends to become depolarized in use, so the element of the spark pump has a finite life in service. The experience so far gained is insufficient for this life to be accurately quoted. According to the Clevite Corporation, however, an element should operate efficiently for at least 10^8 cycles, or over 1,000 hours' continuous operation of the Clinton engine at 3,600 r.p.m. Although this period might not seem particularly long, it should be appreciated that if the engine were used to propel a vehicle at 30 m.p.h, the distance covered during the life of the element would be 30,000 miles. Consequently, the element should last considerably longer than most sparking plugs. In addition, since the cost of renewing the two ceramic rods is little more than that of a plug, there is little to criticize on economic grounds when the low first cost of the spark pump is taken into account.

A good impression of the small dimensions of the Clevite spark pump is given by this illustration. The unit weighs only 8 ounces

On industrial and agricultural engines—the ignition current of which is, of course, normally supplied by a relatively heavy and bulky flywheel magneto—the advantages of the spark pump are manifest. They would, however, be less outstanding in the case of motor vehicles, in which a battery would still be required for the other services. There would appear to be no insuperable problems in the design of units for engines having more than two cylinders. By means of a distributor, one element could be made to fire all the plugs of a four-cylinder engine having a normal speed range, but it might be preferable to use one element for each pair of cylinders, to get a satisfactory life. Correspondingly, a six-cylinder engine could have three elements.

A suggestion has been made that the need for a separate sparking plug might be eliminated by mounting the piezoelectric element directly on the cylinder head, and actuating it by means of the compression pressure. This, in theory, is the ultimate in simplicity but it would introduce practical complications on anything other than a constant-speed, constant-load type of unit : the wide variations in cylinder pressures, and in the stage in the operating cycle at which a given pressure is reached, would seem to demand some form of mechanical timing of the spark. Here again, though, the problems are not insoluble, and this possibility should not be ignored. Finally, mention should be made of the fact that the spark pump is the subject of patents, either granted or applied for, in all major countries.

Transducers

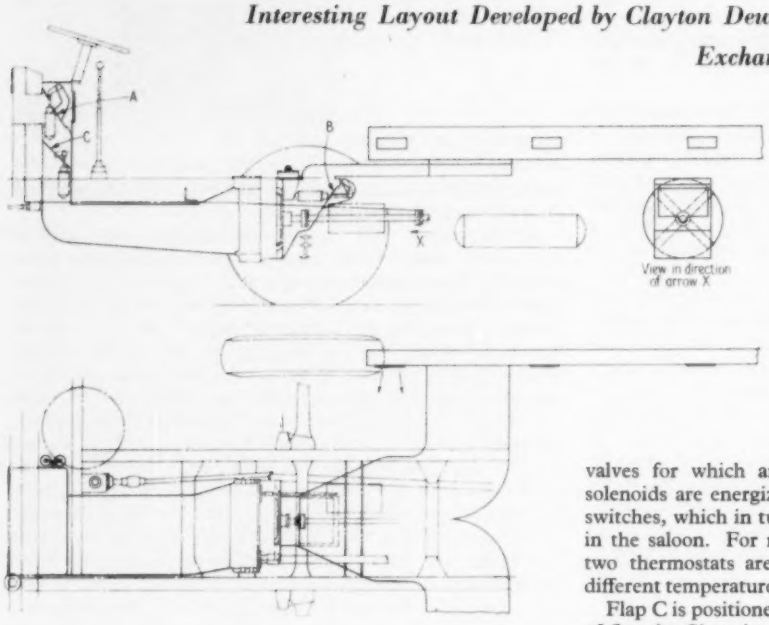
A LIST of the available types of transducers is being compiled by the Analogue Data Processing Technical Committee of the Electronic Engineering Association. Information on not only current types but also those under development is being collated, and so the help of manufacturers or users outside the membership of the Association, who will be given the full results of the survey, is sought. A questionnaire indicating precisely the information required is available to those interested in helping the Association in this way. Application should be made to J. F. Richardson, Technical Secretary, Electronic Engineering Association, the address of which is 11 Green Street, London, W.1.

Double-Sided Tape

A NEW double-sided adhesive tape, Twinstik, has been introduced by the Industrial Adhesives Division of Evode Ltd, Stafford. It consists of a thin tissue impregnated with a special pressure-sensitive adhesive protected by a treated paper. The tape is available in a variety of widths up to 12 in, and is suitable for application to most surfaces. Since there are no solvents in the adhesive, the tape is suitable for use on cellulose and other finishes in common use today.

NOVEL COACH HEATING SYSTEM

Interesting Layout Developed by Clayton Dewandre, in Which Only One Heat Exchanger and Fan Unit is Employed



General arrangement of the coach heating system, the outstanding feature of which is the use of only one heat exchanger, which also serves for engine cooling. Air is drawn through the exchanger by means of a ducted fan, and passes to the saloon through the openings in two longitudinal passages. To control this system, there are three flap valves, and they are actuated by thermostat units and pneumatic jacks

FOR the heating of coaches it is, of course, common practice to employ several small heat exchangers, fed with hot water from the engine cooling system. Fresh or recirculated air passes through these heat exchangers and is blown into the saloon by electric fans. This method has the disadvantages that it increases the load on the electrical generator or battery, and that each unit requires a certain amount of servicing. With the object of overcoming these objections, a new system of heating has been introduced by the Clayton Dewandre Co. Ltd, of Lincoln. In this system, electric motors are dispensed with, as is any heat exchanger other than the engine radiator.

Air is ducted from either inside or outside the vehicle to the radiator, this component being of special design to suit the cowled fan mounted on its downstream side. The fan delivers the heated air into further ducting, which divides to feed two longitudinal passages, mounted one on each side of the saloon at just above floor level. Each of these passages has openings on its inboard face, through which the warmed air enters the saloon.

In the ducting are three flap valves, shown in the accompanying diagrams. The first of these, A, is at the front of the vehicle and has two positions: in one it opens the radiator intake duct to the interior of the coach, so giving recirculation of the air, and in the other it permits fresh air to be drawn in from outside the vehicle. Situated on the downstream side of the radiator is the second flap, B. This also has two positions, whereby the heated air is either delivered through the distribution ducts to the saloon, or discharged to atmosphere. The second position is, of course, used when no interior heating is required.

Both these flaps are moved by pneumatic jacks, the control valves for which are of the solenoid operated type; the solenoids are energized or de-energized by means of micro-switches, which in turn are actuated by thermostats installed in the saloon. For reasons that will be explained later, the two thermostats are set to actuate their micro-switches at different temperatures.

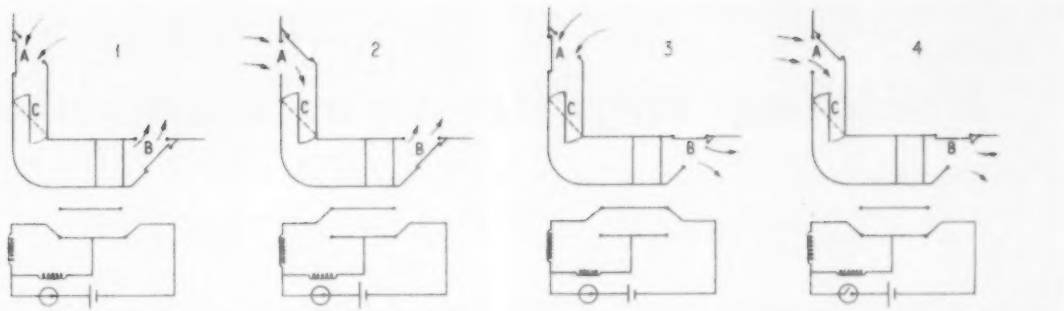
Flap C is positioned in the radiator intake duct downstream of flap A. Since its purpose is to match the rate of air flow with the cooling needs of the engine, its operation is entirely independent of the other two. Another pneumatic jack is employed to regulate the position of the flap, but in this instance its control valve is actuated directly by a thermostat in the cooling system; thus a progressive action is obtained. A rapid warm-up of the coolant is ensured, because the thermostat is set to begin operating at a relatively high temperature, about 130 deg F, and the flap is not fully open until, say, 160 deg F is reached.

Sequence of control

The group of four diagrams illustrates the various control stages. When the engine is started from cold and the saloon temperature is low, the thermostats of flaps A and B are both in their "cold" positions. Hence, both micro-switches are closed and the solenoid coils energized, causing the flaps to occupy the positions shown in diagram 1. Because of the low coolant temperature, flap C is closed and so there is no initial movement of air through the system.

When the coolant temperature exceeds the cutting-in value for the appropriate thermostat, flap C begins to open, thereby allowing recirculation of the air in the saloon, through the radiator. The recirculatory heating rapidly raises the temperature of the saloon. As soon as this temperature reaches a predetermined value, usually about 55 deg F, the thermostat control for flap A comes into operation, causing the flap to be moved to its other position, as shown in diagram 2: this closes the intake from the saloon to the radiator, and causes fresh air to be drawn in, heated and then delivered to the saloon.

Should the temperature of the air in the saloon be raised above a second set value, perhaps 65 deg F, the other thermostat operates. This results in the reversion of flap A to its original, recirculatory position, and the movement of flap B to its other setting—that which permits the heated air to pass to atmosphere—as is shown in diagram 3. To



These diagrams show the positions of the three flap valves, and the appropriate electrical circuit, in each of the four operating conditions. From left to right, these conditions are as follows: recirculatory heating, fresh-air heating, ventilating, and that with the system inoperative. The fourth condition can be selected by means of a switch, and the system reverts to it in the event of any failure of the electrical supply

take the place of the air discharged in this manner, fresh air enters the saloon through louvres in the roof of the vehicle, so it is unnecessary to open any windows.

Owing to normal heat losses from the vehicle, the ambient temperature has to be well above freezing before the saloon temperature can exceed 65 deg F, so the condition in which heated and very cold air enter the saloon alternately is unlikely to occur. In addition, since flap C is progressively opened by its thermostat system as the coolant temperature rises, it cannot hunt between its open and closed positions. When the ambient temperature exceeds 65 deg F, of course, the controls remain continuously in the settings illustrated in diagram 3. It follows that effective ventilation of the saloon is always provided in warm or hot weather, with obvious benefit to the passengers.

There is a master switch in the circuit, between the battery and the two solenoid coils: when it is switched off, flaps A and B adopt the positions shown in diagram 4. No heating is then applied to the saloon, since the fresh air drawn through the radiator is discharged to atmosphere. Should a failure occur in the electrical supply, the system reverts to this condition. Because the control of flap C is independent of the electrical circuit, such a failure has no adverse effect, of course, on the cooling of the engine.

New Ways With Rubber

RECENTLY, a brief, well illustrated guide entitled "New Ways with Rubber" has been published by the Department of Scientific and Industrial Research. In its sixteen pages it surveys the newer types of rubber that are available and describes their industrial applications. Special-purpose synthetic rubbers are available to withstand conditions under which natural or more general-purpose synthetic rubbers would deteriorate. For example: silicone rubber components are useful where there is a risk of fire; solid polyurethanes are among the most versatile of synthetics and are especially valuable where outstanding abrasion resistance is required; fluorinated rubber is another important development and is used in aircraft equipment and in chemical processing. The booklet also contains a useful table giving the general properties of vulcanized rubbers. Copies can be obtained free of charge from the library of the Department of Scientific and Industrial Research, Charles House, 5-11 Regent Street, London, S.W.1.

Deep Drawing Steel

AS IS well known, steel for severe pressing or drawing operations must be of very low nitrogen content, otherwise it age-hardens too quickly. Steels that are produced by the normal Bessemer process, in which an air or oxygen enriched air blast is used, are not entirely satisfactory, owing to the fact that nitrogen is absorbed by the steel from the air that is blown through. The Steel Company of Wales have developed a method, which they term the V.L.N. process, for the production of steel for applications involving deep drawing—the initials comprising the name of the process stand for very low nitrogen.

In this process, a blast of oxygen and steam is employed, so the possibility of nitrogen being picked up from the blast is completely excluded. The nitrogen content of steels produced by this method is only one third of that obtained even in open-hearth products: in fact, the average content is 0·0011 to 0·0012 per cent and, in some instances, is as low as 0·0008 per cent. The nitrogen that is present comes, of course, from the pig iron and scrap. In general, the scrap content is about 4 to 5 per cent and, as a result, the quantities of other elements, such as nickel, copper, chromium and tin, included are low. This latter feature also contributes to the excellent ductility of the end product. If it were desirable, the scrap content could be increased, possibly up to as much as 15 per cent.

Hitherto, it has always been thought necessary, in the production of steel by similar processes, to use an air blast to avoid difficulties with regard to furnace bottom and lining life. However, the Steel Company of Wales took the bold step of installing this plant without air blast equipment. That their policy was justified has been proved by the fact that, after about eighteen months of operation, the plant is producing, regularly, economically and without difficulty, steel of the high quality described. The temperature of the charge is controlled precisely and instantaneously by the adjustment of the oxygen : steam ratio, and this is a marked advantage over other processes. The temperature control effect is obtained largely because the steam dissociates and, in so doing, absorbs heat from the contents of the furnace.

Lighting Control

AN AUTOMATIC control for the lighting in factories and offices has been introduced by Elcontrol Ltd, of Wilbury Way, Hitchin, Herts. It is a simple and robust unit designed for switching lighting or other circuits at predetermined levels of rising and falling daylight. The control is effected by a small self-contained photo-electric amplifier. A data sheet is obtainable from the makers.

Building Replacement Engines

A Separate, Specially Equipped Plant to Operate, on a Line-production Basis, the Perkins Perpetuity Plan, Now Turns Out More Than 10,000 Reconditioned Diesel Units Per Annum

WHEN the Perpetuity Plan was introduced in 1938, F. Perkins Ltd, of Peterborough, the parent manufacturing company of what is now the Perkins Group, had already established a reputation for the supply of replacement engines having specification, performance, and guarantee equal to those of a new engine. The aim of the plan was to make the service available to owners and operators all over the world, to extend its facilities and, by rationalizing production, to keep the cost of replacement units as low as possible. In naming the plan, the word "perpetuity" was chosen as most aptly describing a main feature of the scheme; no limit is imposed on the number of times an engine can be replaced. Right of replacement is vested in the engine; it is immaterial if the owner at any time was the original purchaser or acquired the unit second- or third-hand. No stipulation is made regarding the period of service before a replacement is effected; the decision on this point rests entirely with the operator. On request, a replacement unit can be made available to the operator before the worn engine is returned, thus the changeover can be effected immediately and a vehicle need be withdrawn from service for a single day only.

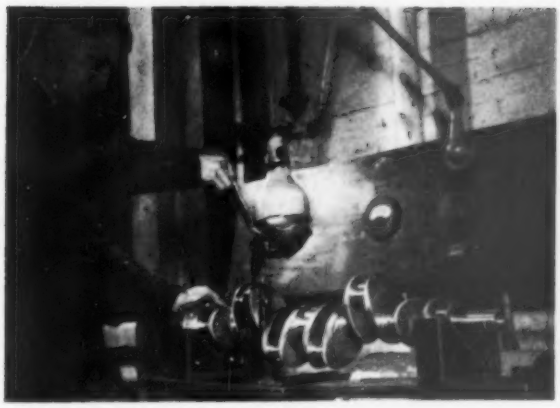
As regards the engines traded in against a replacement, certain parts and components are invariably consigned to scrap, while the potentially serviceable parts are pooled. Subsequently, those parts found to be usable are machined, inspected and tested to the same standards as are new parts in original manufacture.

In so far as it is practical, a replacement engine includes the latest modifications and consequently the factor of obsolescence is eliminated. Rebuilt engines are finally checked for performance by running the standard test routine for new engines in the test shop of the main manufacturing plant. Tested units are held in store against demand in the main plant and also by approved distributors and dealers in the U.K. and overseas in suitable locations. The exchange, of course, is solely on a type-for-type basis. Worn engines are returned minus flywheel, flywheel housing, fan, fan extension, electrical equipment, air cleaner, and heater plug; replacement engines are not fitted with these items.

Each succeeding year from the inception of the plan the output increased and in 1945 a total of 269 replacement engines were supplied. Production took on its present shape and methods in 1947, when the Company opened its new manufacturing plant at Eastfield, outside Peterborough. A major part, 150,000 ft², of the original Queen Street factory in the centre of the city was laid out and equipped to build replacement engines at an increasing rate. By 1954 production had risen to 5,000 units per annum and 10,500 came off the assembly lines in 1959. Production facilities and methods are under constant review in order to fit them to meet increasing demands for reconditioned engines.

A Mills 30-ton hydraulic press is used to insert new dry-type liners

Cylinder water jackets are tested for leaks at a pressure of 30 lbf/in²



After a preliminary dimensional check, all crankshafts are magnetically tested for cracks before regrinding

All connecting rods are mounted on a special rig and examined for flaws by the magnetic detection method

On arrival at the plant a worn engine is first checked for completeness and any missing parts are noted. Such items are requested from the owner and if not forthcoming are duly provided at an additional cost to the standard charge for a replacement unit. Engines are grouped in batches of five of each type, and each is mounted on a wheeled, turnover cradle. As a preliminary measure to remove external dirt and oil, they are cleaned down by a steam jenny and are then passed on to a track for stripping.

Cylinder block, cylinder head, crankcase, crankshaft, and main bearing caps are the only parts to be identified—all others are pooled. All assemblies are stripped down to individual items and major nuts are retrieved. The cylinder head is lifted off by an air hoist and is transferred to a bench for dismantling, removing valves, guides, and combustion chamber chaps. From the main block all external components are taken off and the cylinder-head studs are withdrawn. The timing chain and sprockets are dismantled and the chain is checked for stretch to ascertain if it is usable or requires to be scrapped.

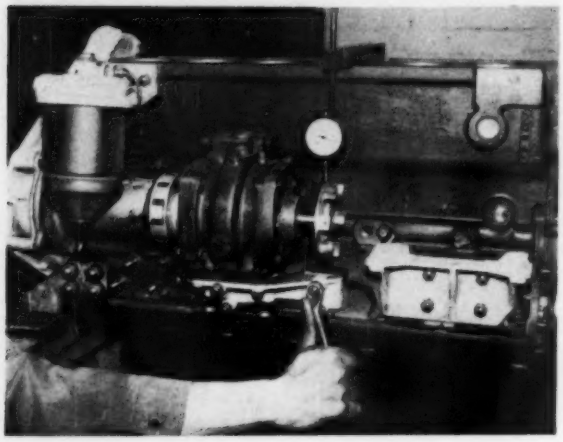
After inverting the block, the oil sump, crankcase, oil strainer, oil pump, main bearing caps and connecting rod caps are removed. Bearing caps are wired together for identification and pistons and connecting rods are pushed out through the cylinder bores. Pistons, bearings, and gudgeon pins are discarded 100 per cent as scrap. Rods and caps are mated again and collected in a wire basket for cleaning and inspection. Cylinder block, cylinder head, crankshaft and other relatively large parts of ferrous metal are passed through an I.C.I. trichloroethylene degreasing plant. Small parts are collected into baskets and cleaned in individual tanks containing appropriate cleansing agents for ferrous and non-ferrous materials. All parts are finally traversed through a Dawson machine for a hot, alkaline spray wash.

In the case of an engine that has suffered severe damage or breakage for any reason, whether the condition was reported or not, an individual strip is made and all parts are retained for a special inspection. It is implicit in the scheme, of course, that the used engine returned in part exchange for a rebuilt unit at standard cost should have been subjected only to normal wear and tear and not to such accidents as collision, fire, or total submersion.

All parts are then given a preliminary inspection. Small parts are checked by standard gauges and grouped for conformity and re-issue, rectification to approved standards, or relegation to scrap. Stressed components, including crankshafts, cylinder-head studs, connecting rods, valves, camshafts, main bearing bolts, and other items, are magnetically tested for cracks. In connection with these inspections a close liaison is maintained with the engineering department of the main manufacturing plant. Any substantial variation in the percentage of rejects of a particular component is compared with recorded experience and referred to the engineering department for investigation and, if found necessary, corrective action. After inspection, small parts are delivered to the sub-assembly benches and major components to the machining lines.

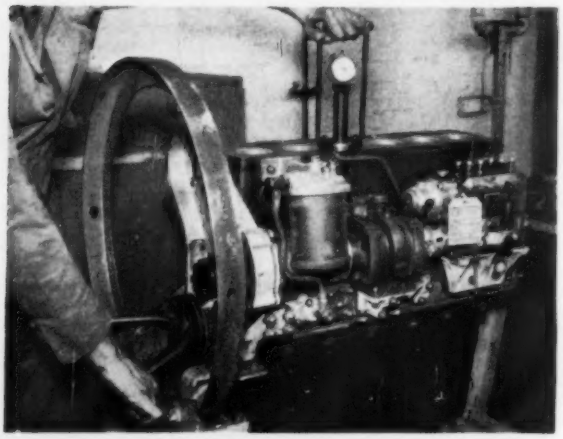
On a Mills 30-ton hydraulic press all liners are removed from the cylinder block and relegated to scrap. A roll-over fixture turns the block 180 deg from the inverted position and the casting is passed along a roller track to a test station at the rear of the press where it is subjected to a cold water pressure test at 30 lb/in^2. Should the slightest crack or porosity in the jacket be revealed under this test the casting is discarded; cylinder blocks are never welded. A visual

Liner bores are finished individually on a Kitchen and Wade honing machine

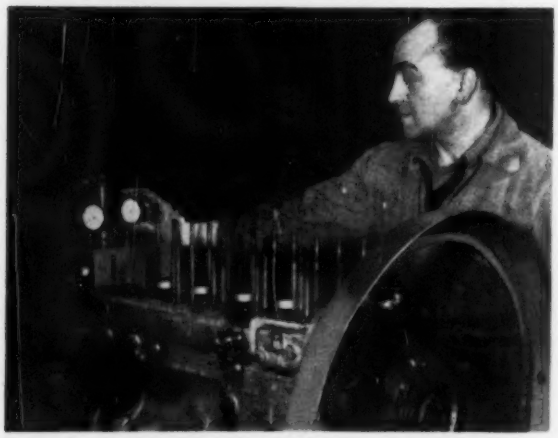


Above: Mounting auxiliary components and aligning their drives with the aid of a dial indicator seated on the cylinder block joint face

Below: Measuring from crankpin to joint face to determine precise height of piston crown required to obtain uniformity of compression volumes



A dial-indicating device, seated on the joint face and contacting a cam and a piston, facilitates rapid and precise timing of the engine



inspection of the parent bores is made and the block is then returned to the press to be fitted with new liners drawn from a buffer storage track alongside. Each dry-type liner is inserted by a pressure of 2½ tons.

Continuing on the roller track, the block is taken to either a 6-spindle or 4-spindle Kitchen and Wade boring machine and bored to rough diameter. Next it is passed to a Kitchen and Wade single-spindle honing machine and rough honed to leave 0·002 in on the finish diameter. Dimensions are checked by a dial gauge, set in a master ring gauge. The block is then rested for sixteen hours, in a roller-track storage section, before the second honing operation to bring the bore to final size and surface finish.

After inversion in another roll-over device, the block passes along a roller track to a station where the new main bearings are fitted. The seating bores are measured with dial indicators and when the bearings, shimmed ready for boring, are in position the caps are checked to 0·003 in for nip. Caps are then secured by tightening the bearing set bolts with a pre-set, torque-limiting wrench to obviate risk of damage. Bearings are then line bored on a Heald Borematic machine. Only one cut is taken to finish size; the feed being 0·005 in/rev running at 200 r.p.m. On leaving the boring machine, caps, bolts, and half shells are removed, oil grooves are frazed, and all these parts are collected in a basket for cleaning and transfer to the assembly line.

A crankshaft is reground to one of three standard undersize dimensions, −0·010, −0·020, or −0·030 in on both journals and pins, as is found necessary. If a shaft that had been machined to the lowest standard is returned on the replacement plan it is invariably scrapped. The grinding of journals and pins are independent operations, journals being ground on a Churchill crankshaft grinder and pins on a Prince No. 2 oscillating-spindle machine.* After grinding, oil holes breaking into the bearing surfaces are opened up and finally the surfaces are polished to a mirror finish by linishing.

Block, crankshaft and basket of components are passed through a Dawson washer for a hot spray wash; 140 deg F spray at a pressure of 18 lb/in^2. After washing and draining, all oil ducts and drillings, and bolt and screw holes, are blown out by means of a manually operated C.A. jet. The block is then mounted on a turnover-type assembly stand. A new number for the rebuilt unit is stamped on both sides of the block.

Simultaneously with these operations on the major components, work proceeds on the sub-assembly benches in the inspecting, adjusting, servicing and re-assembly of minor and auxiliary components. Connecting rods that have passed inspection are fitted with new big- and small-end bearings which are bored in a single setting on a Heald twin-spindle, fine-boring machine. These rods are matched for weight before being grouped into sets for individual engines.

On the cyclinder head, valve seats are examined and any that are badly worn or ground down below standard are extracted and scrapped. New seats, valve guides and valves are fitted, as necessary. Oil pumps are inspected and regulated to deliver two pints of oil at a temperature of 150 deg F in 17 sec. Oil pressure relief valves are set to break at 65-70 lb/in^2. Water pumps are tested for leaks. Oil sumps are checked for leaks with paraffin.

On the assembly line, the mobile assembly stands are carried along by the powered conveyor at a speed that allows each operator to complete his specific task without leaving his station. Sub-assembly lines are synchronized with the main line, and components and sub-assemblies are fed to benches alongside the track and opposite their appropriate assembly station. The stands enable the engine block to be revolved through 360 deg and held securely at any angle.

* "*Automobile Engineer*", February 1955

Replacement engines nearing completion on the final section of a main assembly track at the Queen Street plant

The first assembly operation is to fit the rear oil seal. This unit is not registered on the block but is centred on a mandrel located in the two rearmost main bearings before being secured. When fitting the crankshaft, the thrust washer is arranged to allow an end float of up to 0·0045 in where thick-wall bearings are used and up to 0·010 in on blocks having thin-wall bearings. Caps are fitted to their specifically numbered seatings and the bolts are tightened down with a torque-limiting wrench.

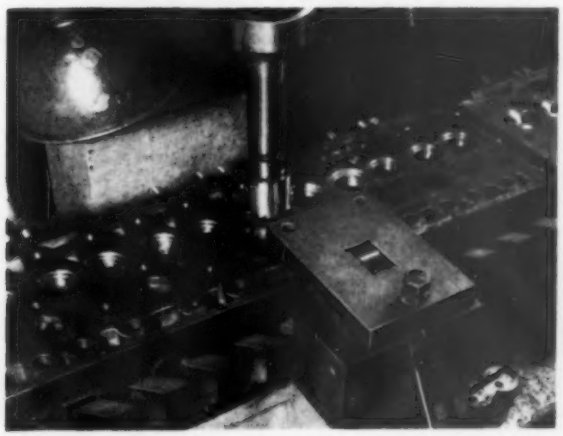
To ensure uniformity in the volume of the compression space for each cylinder, a dial-indicating, checking fixture is used to measure the distance from the crankpin at T.D.C. to the top joint face of the block. From this dimension is obtained the precise height, from gudgeon pin bore to crown, required on the new piston for each cylinder. A card listing these dimensions is made out, and from it a set of pistons is prepared by skimming the crowns to suit. Each piston is marked and, after cleaning, the set is boxed and delivered to the assembly line.

Individual care is taken to obtain correct alignment of side-mounted auxiliary equipment and the concentricity of auxiliary drives. A checking device seated on the top joint face of the block carries a dial gauge, and the shaft or coupling of each item is rotated against this gauge. Any indication of ecentricity or run out is corrected by adjustment of the component on its mounting.

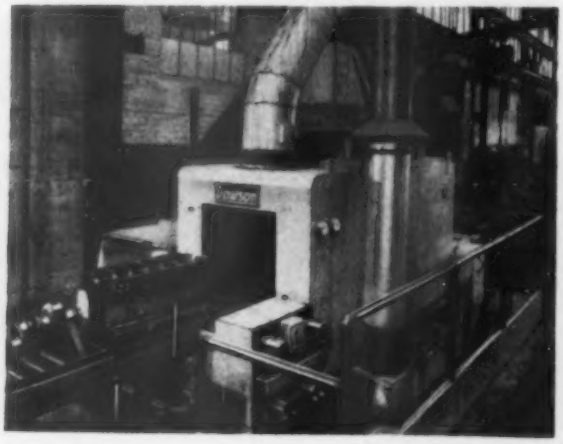
Dial indicating equipment located from the top face is also used for timing the engine. Its use virtually eliminates the likelihood of error. Separate dial gauges over a piston and a cam indicate the relative angular positions of crankshaft and camshaft. The same device, used with a packing block, also serves to time the point of spill in the pre-set fuel injection pump.

On completion of assembly the engine is inspected and checked for specification before being passed out. Since the replacement scheme guarantees performance as well as specification, the engine is then transported to the main plant at Eastfield for testing. There, before being tested, each engine is carefully examined, crankcases are charged with oil to ½ in above "full" level, auxiliary drives are checked for lubrication, the rocker shaft assembly is checked, and oil filters and fuel pumps are primed in readiness for running.

Machining a cylinder head prior to fitting new valve insert seats



Dawson washing plants are used to cleanse parts before re-assembly



View of part of the test shop at the Eastfield plant where both new and reconditioned engines undergo similar tests

When mounted on the Heenan and Froude dynamometers, the reconditioned engines are first run under their own power, with no load, to ascertain that the lubricating oil system is working correctly. Next, a load is applied and the engine speed increased. At the end of this running-in period the cylinder-head nuts are checked for tightness and the valve tappet clearances are set to 0·010 in. Injector nozzles are checked and, if necessary, adjusted at this stage before the engine speed is further increased. A check is then made to see that the unit is producing the power output specified for this engine speed. During the next stage of testing, the speed is increased to the maximum for the engine's particular application and the output is again checked. Further checking and testing is carried out to ensure that the fuel pump is at the optimum setting, that fuel consumption is correct, and that the unit is performing adequately throughout a wide range of engine speeds. Tests are also carried out at idling speed, when the lubricating oil pump pressure is checked at a given oil temperature. Provided all tests are satisfactorily completed, engines pass off test, are drained, masked, painted and stored for dispatch.

Main-bearing and other bolts are uniformly torqued by preset wrenches

All the fuel injection equipment fitted to replacement engines is completely overhauled in a specially constructed and equipped department at the Eastfield factory. For testing fuel pumps and their components there are 10 U-type Hartridge machines, pressure spill-phasing machines, machines for testing pump elements, high pressure testing equipment and a delivery-valve testing unit. When a pump has been reconditioned, it is expected it will be trouble free and it is covered by the same guarantee as a new pump.

Specifications for Rubber Products

RAPID advances in rubber technology have made it difficult for engineers and even specialists to keep abreast of the full range of developments. Consequently, rubber manufacturers have for some time been concerned at the number of specifications commonly encountered that are inadequate for and, occasionally, even prejudicial to the effectiveness of the material for its application. Accordingly, the Federation of British Rubber and Allied Manufacturers recently set up a Specifications Advisory Committee to examine the problem and devise means whereby the knowledge and experience of the rubber manufacturers might become more fully accessible to designers and others in industry. As a first step in rationalizing the confusion of ideas and information that exists, a short Guide to the Drafting of Specifications for Rubber Products has been published, and copies are available free of charge from the Secretary, 43 Bedford Square, London, W.C.1.

British Standards, wherever they are available and suitable, are recommended by the Guide, especially where standard tests are concerned: the latter are set out in B.S. 903. Advice is given on the most suitable kinds of performance tests for the user to employ, quality control tests for the manufacturer, and on dimensional tolerances applicable to different types of components. The importance of consulting the manufacturer, or a qualified rubber technologist, at the earliest possible stage is stressed. A series of questionnaires is attached to the Guide, indicating in detail, for each category of rubber product, information on function, properties and service conditions that will be needed for the drafting of a fully effective specification.

New Plant and Tools

Recent Interesting Developments in Production Equipment

ORIGINALLY designed, patented, and developed by the Lanzoni Co, of Mantova, Italy, a machine for lapping diesel fuel injector nozzle seats and also for precision grinding the conical faces of injector needles is now produced exclusively in the United Kingdom, world-wide manufacturing rights having been acquired by Diesel Injection Ltd, of Ruddington, Nottinghamshire. The dual-spindle machine is powered by a multi-voltage electric motor of 0·25 h.p. and is arranged for bench mounting.

Lapping of nozzle seats is effected by steel mandrels terminating in conical laps of cast iron. The mandrel is guided in the main bore of the nozzle body and a wide range of mandrels of differing diameters and lengths is available to meet all requirements. Production can be rapid as two seats can be lapped simultaneously.

Mounted at the rear of the machine, directly above the driving motor, is a vertical spindle carrying two grinding wheels. These are used for successive grinding and finishing operations on the cast iron seating laps and also on the coned faces of the injector needles. Lapping mandrels or needles are supported in a carrier that is adjustable to permit grinding at angles ranging from 57 deg to 62 deg. Rotation of the part being treated is by a roller driven by a flexible shaft from the head of the lapping machine. Only a single setting of the part is necessary for both grinding and finishing operations.

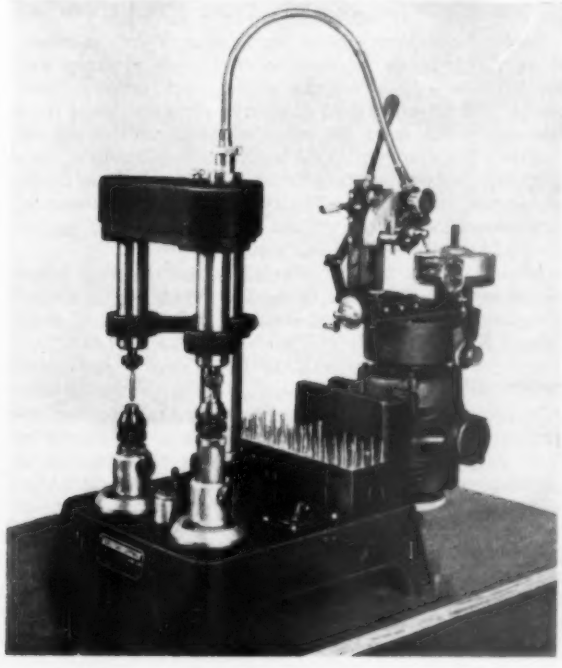
Basic dimensions are 380 mm wide and 580 mm long, and the height of the machine, not including the flexible drive shaft, is 530 mm. All rotating parts are mounted on ball bearings. Standard equipment includes a mounted diamond for wheel truing, and the machine is supplied with a full range of mandrels with mounted laps for long and short injectors. It can be used for injectors of hole, pintle, or flat-seating types, with equal efficiency.

Shell core blower

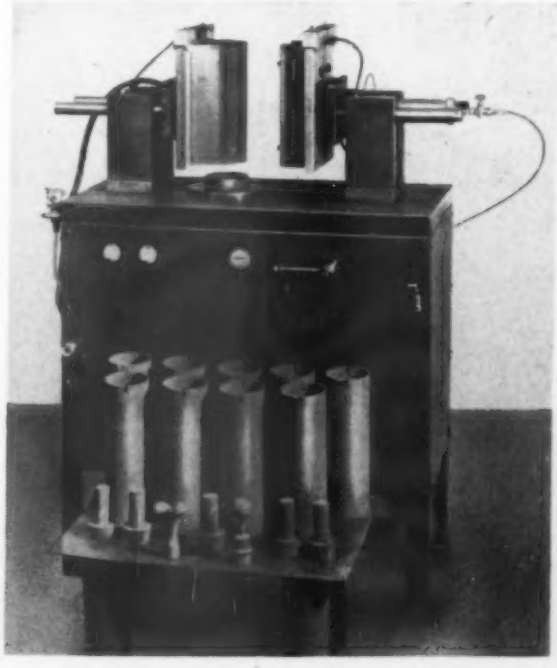
Shell cores have only a fraction of the weight of solid cores, and the reduction in the quantity of material required and the elimination of mixing operations more than compensate for the higher cost of the resin-bonded sand. The cores are strong, when completed are ready for immediate use, and have a prolonged storage life. Vents, support wires, and driers are not required. Foundry and Metallurgical Equipment Co. Ltd, of Netherby, Queens Road, Weybridge, Surrey, have produced a new machine, the Reynolds shell core blower, that can operate at speeds up to 180 blows per hour. The actual output rate, of course, depends on the type of core and the number of cores per box.

The blower is enclosed in a free-standing cabinet surmounted by two heads for supporting the halves of the core box. These heads are accurately aligned on a heavy, cast iron table to ensure rigidity and constant register of the box halves in operation. Both the height of the heads and the gap between them can be adjusted to suit the core box being used. Mounted on the heads are the light alloy plates to which the box halves are attached. The plate on the left is fixedly mounted and the right-hand plate is moved

Lapping machine for diesel injector nozzles and needles
(Diesel Injection Ltd.)



Reynolds shell core blower. Typical cores are shown
(Foundry and Metallurgical Equipment Co. Ltd.)



horizontally by a pneumatic cylinder to open and close the box. Electrical heating elements, operating on standard, single-phase supply, are cast in the aluminium plates and the heat input is controlled by an energy regulator to suit the size of the core box.

Housed beneath the table is the steel, cylindrical sand chamber which is raised and lowered by a pneumatic cylinder through a linkage system. As standard, the chamber has a sand capacity of 35 lb but larger chambers can be supplied. Also available is an attachment to allow the use of three-part core boxes.

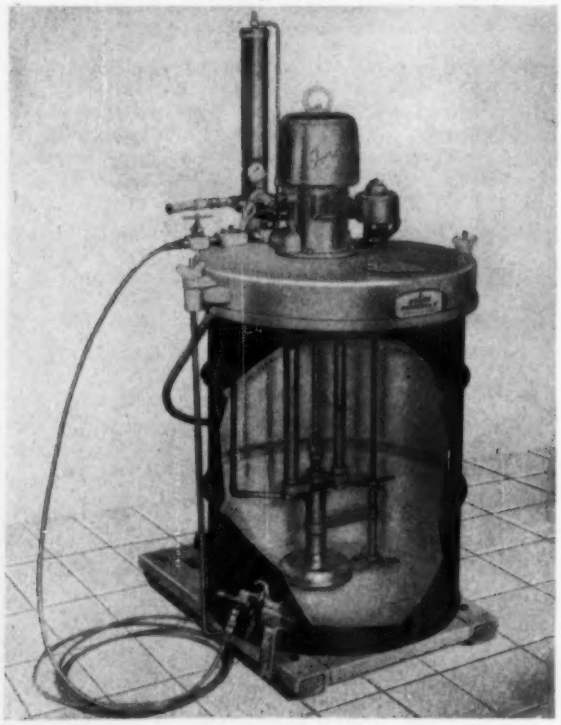
Control of the machine is simple; all operations are completed in correct sequence by means of a six-position lever. The box is closed, the sand chamber raised to seal the box entry, and the cores blown. Then the air is exhausted from the sand chamber, the chamber is lowered, and the box opened for the removal of cores. A pneumatic vibrator, push-button operated, empties sand from the cured shells and an automatic air blower nozzle clears residual sand from working surfaces.

Hydrostatic paint-spraying equipment

Arranged for operation direct from a 44-gallon, open-top shipping drum, the American-built Graco Model 226-066 Hydra-Spray unit is skid mounted to facilitate changes of location. Changing of paint drums is made easy and rapid by the provision of an air-operated elevator that raises and lowers the complete drum-head assembly. When in position, the head fits snugly over the drum and is secured by two hold-down rods. The ingress of dust and dirt to the paint is thus prevented, and access to the interior for inspection is by way of a covered port.

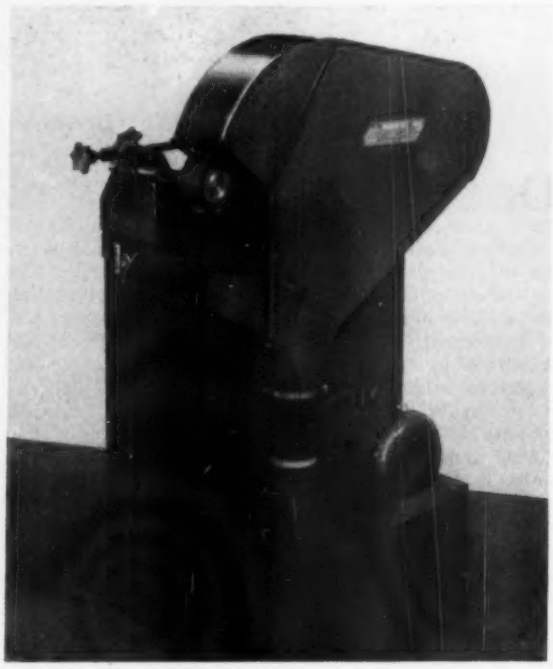
Operation is on the cold, airless system which, of course, eliminates any risk of fire arising from the use of paint heaters. The necessary high operating pressures are attained by means of a reciprocating, double-acting air motor driving, by means of a coupling rod, a reciprocating, double-acting pump. The pressure ratio through this aggregate is 20 : 1, and an air line pressure of 90 lb/in^2, for example, develops a paint pressure of 1,800 lb/in^2. In spite of the very high hydrostatic pressures at which the pump operates—up to 3,000 lb/in^2 is possible—there is no need to use anything other than the usual shipping drum as the paint container. These pressures are confined to the pump, the 20 ft length of Teflon tube, and the spray gun.

Graco Model 226-066 hydrostatic paint spray unit
(Alfred Bullows and Sons Ltd.)



When released through the small orifice of the gun nozzle at such high pressures, paint is very finely atomized and projected at a high velocity to the work target. Since compressed air is not used to atomize the paint, there is no rebound of air from the work surface and virtually no bounce or overspray. This method of application, consequently, is faster, gives a better and more uniform finish, and is more economical. The saving in paint, it is claimed, is approximately three gallons out of every ten gallons sprayed by more conventional methods.

Model 226-066 unit is included in the range of Graco equipment which is now being distributed in the United Kingdom solely by Alfred Bullows and Sons Ltd, Long Street, Walsall.



Morrisflex Model MA.160 backstand grinder
(B. O. Morris Ltd.)

Backstand grinder

A compact, self-contained, abrasive-band machine for light, freehand grinding has recently been introduced by B. O. Morris Ltd, Briton Road, Coventry. It comprises an assembly of two well-established units; the Model M.160 backstand grinder and the Model M.475 dust extractor, complete with hoods and trunking. The basic machine, powered by either a 1 h.p, 3-phase, or $\frac{3}{4}$ h.p, single-phase, totally enclosed, fan-cooled motor, drives a 5 ft abrasive belt over a contact wheel and a jockey pulley. Belts may be either 1 in or 2 in wide and the linear speed is constant at 6,000 ft/min. Serving also as a pedestal for the machine,

the dust extractor is driven by a separate ¾ h.p. motor and has a capacity of 475 ft³/min.

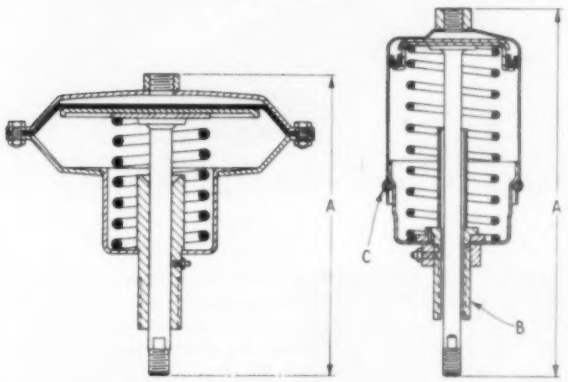
Standard equipment includes a set of four rubber contact wheels ranging from 1¼ in diameter by 1 in wide to 4 in diameter by 2 in wide. A Shearflex wheel, also 4 in diameter by 2 in wide, can be provided for heavy duties. If desired, the machine can be fitted with a special spindle arranged to mount a grinding wheel or wire brush on the left of the contact wheel, and a collet for mounted points or rotary burrs to the right of the wheel.

Short stroke thrusters

Problems with regard to accommodation can arise when the space available is limited and complex lever systems or special actuating mechanisms are employed for heavy thrust operations involving short stroke clamping, lifting, pushing or holding. To obviate this difficulty and also to simplify these operations, P. L. Willcox Ltd, Standard Works, Tyseley, Birmingham, are manufacturing two ranges of pneumatic thrusters, operated on 80-90 lb/in² air line pressure.

The illustration on the left is of one of the diaphragm-operated range. In this range are four sizes: the smallest is 5·7 in overall diameter, with 1·181 in stroke and 660 lb thrust, and the largest 13·9 in diameter, with 1·969 in stroke and 5,500 lb thrust. When the mechanisms are in the rest position, the overall heights, dimension A, are respectively 7·6 in and 13·6 in; the weights of the thrusters range from 4 to 48 lb. The piston-operated type is of smaller diameter and longer stroke than the other. In this range there are only two sizes, and they are intended for applications that call for less power than the diaphragm thrusters are able to provide. Of the two, the smaller is 2·7 in diameter, its stroke 2·165 in

Sectional views of two pneumatically operated short stroke thrusters
(P. L. Willcox Ltd.)



and its thrust 350 lb, whereas the larger has a diameter of 3·7 in, with a 2·363 in stroke and 660 lb thrust. The weights are 2·4 lb and 4 lb, and overall heights 8·8 in and 10·4 in respectively. Both types of thrusters have an externally threaded portion B on the piston rod guide, which is for the mounting of the unit in a hole in channel or angle-section beams. Positive location is then provided by nuts tightened against each side of the flange of the beam.

In each type of thruster a return spring is incorporated between the piston and the end of the cylinder, and a lubricator for the piston rod is set in the flank of the guide. The illustrations show, at the top, the holes for entry of compressed air, with the thrusters in the "off" position, and return springs fully extended. In the diaphragm type of thruster, a ring of bolts serves the dual purpose of holding two dished members together to form the pressure chamber,

Hand spray gun for cleaning and lubricating pressure dies
(Foundry and Metallurgical Equipment Co. Ltd.)

and of retaining and sealing the diaphragm, which is of toughened oil resistant plastics material. The cylinder for the piston-type thruster is held in place by a ring C divided diametrically in two: these two pieces seat in an interior annular groove pressed in the wall of the cylinder. This ring, under the action of air pressure inside the cylinder, or of spring pressure when air is switched off, abuts against a shoulder formed on the base pressing, which is incorporated in the piston rod guide assembly. To remove the cylinder, it is necessary merely to press it towards the guide, when the locating segments of the ring will fall free.

Spray gun for dies

Designed especially for use with pressure die casting machines, the hand spray gun produced by Foundry and Metallurgical Equipment Ltd, Queen's Road, Weybridge, Surrey, is provided with an air jet for cleaning the dies and an oil spray for giving efficient die lubrication. These two functions are independently controlled, and are applied at right angles to die faces so that penetration into deep cavities is assured. The control valves are of stainless steel, and the spray density can be adjusted and then locked at the required setting.

Two types of head are available, one with a single- and the other with a double-facing action, the latter for spraying two dies simultaneously. Carried on each type of head is a phosphor bronze scraper blade for cleaning flash from dies, and a hook for hanging up the gun between operations. Tubes in lengths of 8 in, 12 in and 18 in are available, and the gun is supplied complete with a 1-gal oil container and two armoured hoses 6 ft long.

Truform grinding machines

A method of finishing parts with consistent repetitive precision is provided by the Matrix Thompson Truform grinding machine, which is manufactured in this country by Coventry Gauge and Tool Co. Ltd, under licence from The Thompson Grinder Co, Springfield, Ohio, U.S.A. The grinding wheel takes its profile from a preformed crushing roll that is located at one end of the work table, and it then transfers this profile to the work. When, after a number of crush-forming operations, the roll begins to lose its form, the grinding wheel is trued up on a master crushing roll at the other end of the table. The wheel is then used to regrind the first, or service, roll. For this operation the roll is power driven, whereas in the normal crush forming process it is allowed to rotate freely. Re-processing of the service roll is carried out without disturbing the work set-up, and, since both this roll and the master roll are in alignment, initial accuracy is restored with minimum down-time.

A drive unit incorporated in the wheel head rotates the grinding wheel at an appropriate low speed for crush-forming, and an automatic, timed down-feed is incorporated. The wheel is 14 in diameter and 2 in wide, and it is driven by a 5 h.p. motor operating at 1,500 r.p.m. Beneath the wheel, the maximum height is 16 in. A patented elevating nut ensures rapid and accurate positioning of the wheel head, and a micrometer back-up stop graduated in 0·0001 in divisions is fitted to the elevating handwheel. A steplessly variable drive provides speeds from 3 in/min to 75 ft/min for the table, which traverses on automatically lubricated vee and flat ways whose length, to ensure stability even at maximum traverses, is twice that of the work table.

Incorporated in the Matrix Thompson Truform Grinding Machine is the patented "Hydra-Cool" system, which is particularly useful in applications calling for long production runs and close tolerances. By eliminating the heat at its source, the Hydra-Cool system prevents harmful distortion, especially in the work table area. There are no external relief valves, and oil supply is automatically regulated to the requirements of the machine. Thus, there is never more than the required pressure or volume of oil pumped, and no excess energy to be dissipated as heat.

Crushing rolls can be supplied to suit customers' requirements, and various auxiliary equipment is available for these machines, including automatic cycling feeds, circular form attachments and rolled thread die fixtures. The sole selling agents in the U.K. are Rockwell Machine Tool Co. Ltd, Welsh Harp, Edgware Road, London, N.W.2.

Needle roller tracks

For applications where sliding friction would be too high to be acceptable, the Nadella company have designed needle roller tracks that can be supplied in short assemblies and readily linked together to make up any desired length. Each track consists of a row of trunnion-ended rollers enclosed in a cage. The ends of the cage are turned up so that they can hook on to the ends of the adjacent tracks. These components are produced in two sizes—one 30 mm long × 11·3 mm wide, and the other 48 mm × 17·8 mm—and they have been specially developed for use in machine slideways and other applications involving similar movements.

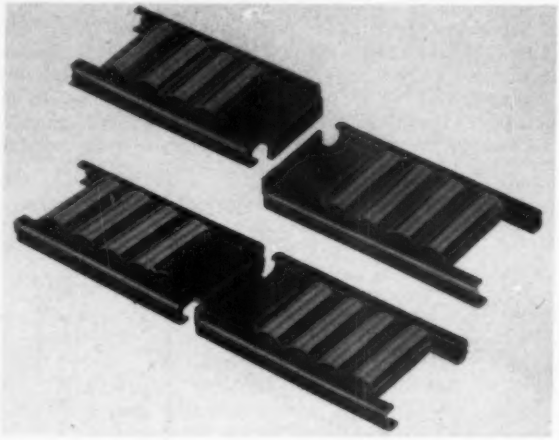
A high load capacity is claimed for the tracks when they are used on hardened slideways, but for light duty and applications where the requirements in respect of precision are not so exacting they may be used on unhardened or cast-iron surfaces. They can be used on horizontal, vertical, inclined or dovetail slides. Their travel is, of course, half that of the moving member that bears on them, so they must be free to move over the distance without being allowed to deviate from the correct path. Stops extending across the full width of needle track should be provided at the end of each slideway.

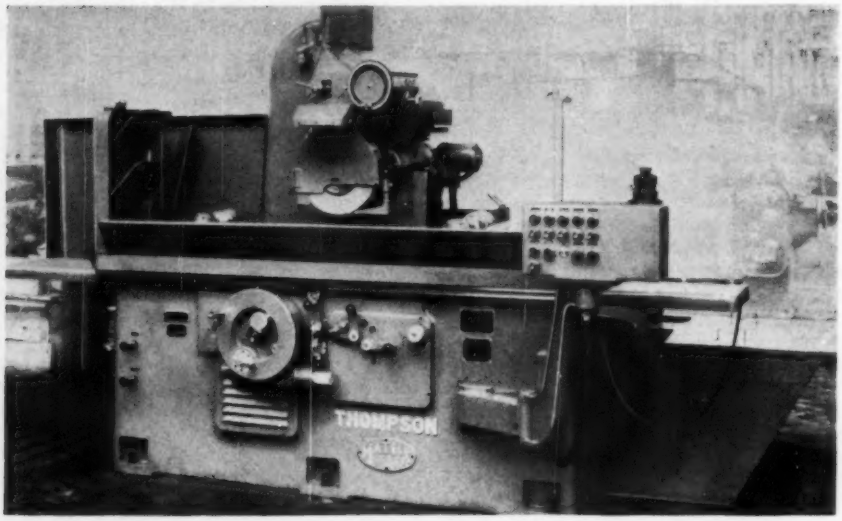
Insley Industrial Supply Co. Ltd, 21/22 Poland Street, London, W.1, are distributors in the U.K. for these and other needle roller bearings produced by the Nadella company, of France.

A hard lapping abrasive

A new synthetic abrasive, called "Macolaepp", is now on the market, and a claim is made that the hardness of its grains is second only to that of diamond. Macolaepp, with a hardness of 9·5-9·8 on the MOHS scale, compared with the 10 of diamond, is therefore harder than sintered carbides or silicon carbide, and is considerably less costly than diamond. Since the abrasive does not clog or fill up, it can be used with undiminished efficiency down to the last layer of grains.

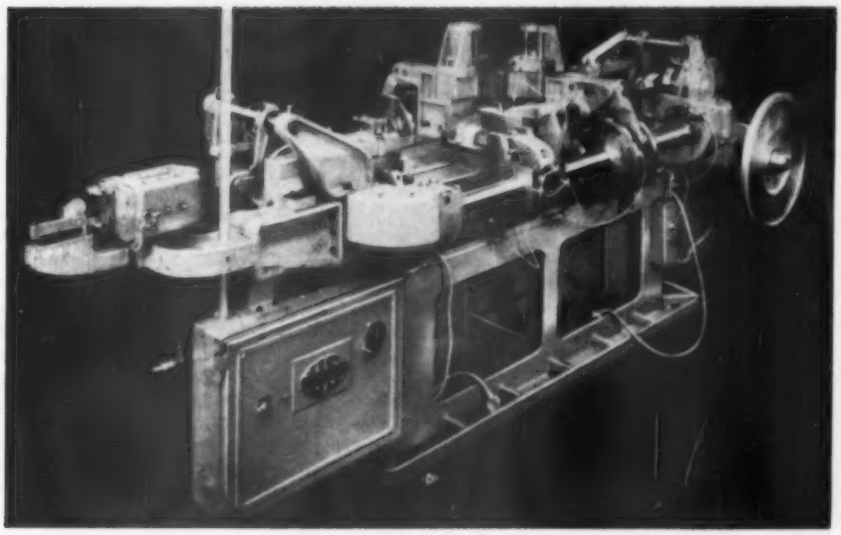
Laps of this material do not suffer permanent damage if they become deformed through abuse or incorrect use on





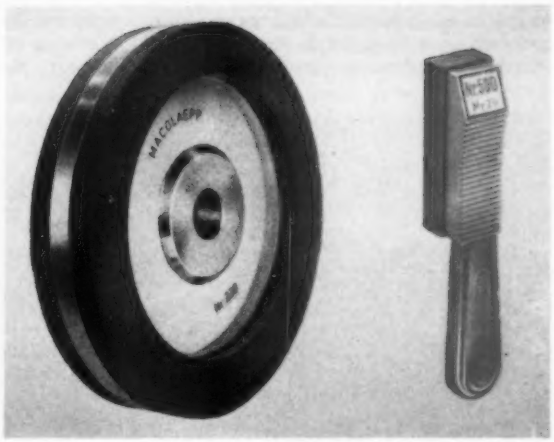
Above: Nadella needle roller track assemblies
(Insley Industrial Supply Co. Ltd.)

Left: Matrix Thompson Truform grinding machine
(Rockwell Machine Tool Co. Ltd.)



Right: No. 36D U.S. Duplex Multi-Slide Machine
(Rockwell Machine Tool Co. Ltd.)

Below: Macolaepp lapping wheel and hand lap
(Monks & Crane Ltd.)



carbide or steel tools, since the flat surface can be restored by lapping one against another. This new abrasive is available in four grades and can be used in three ways: hand laps, lapping wheels or solid lapping stones. The sole British distributor is Monks and Crane Ltd, Garretts Green Lane, Birmingham 33.

Duplex Multi-Slide machine

As an addition to their range of Multi-Slide machines for producing intricate formed stampings, the U.S. Tool Company, Inc, Ampere, East Orange, New Jersey, U.S.A, have introduced the No. 36D U.S. Duplex Multi-Slide machine, which is a unit developed from, and more versatile than, the standard No. 35 model. It is, in effect, a double-ended machine into which strip material is fed at both ends, and the design is such that two stampings, which need not be duplicates, can be made simultaneously. These two stampings can be brought together, by the machine, either to form an assembly or to be assembled with a third, hopper-fed component. Alternatively, if a reduction in output is called for, a single feed can be utilized, and the machine tooled at one end only, to form single components instead of the pairs.

The machine handles stock up to 3 in wide and $\frac{3}{16}$ in thick, and the feed length at each end is separately adjustable up to a maximum of 6 in. Each end of the machine has a stock straightener, slide-feed mechanism and stock check, and each section has a 25-ton capacity die head. There is one four-slide forming position and a common stripper unit with double motion. The die heads can be operated from either of the two camshafts, and each section of the machine can be equipped with an extra die head, a cut-off slide and a rear auxiliary slide in addition to the standard equipment. Power for the machine is transmitted through a variable speed drive unit by a 7½ h.p. motor; the clutches and brakes are air-operated.

British agents for the machine are Rockwell Machine Tool Co, Welsh Harp, Edgware Road, London, N.W.2.

Red Line Prints

FOR experimental work in drawing offices, use is frequently made in other countries of printing paper giving red lines instead of black or blue ones. This red line paper is preferred because it gives greater legibility on prints taken from the relatively faint pencil tracings that are often encountered in this work. An additional advantage is the immediate visual segregation of experimental drawings. Since the red lines are opaque to the actinic light of photoprinting machines, prints of this type can be used as masters for taking extra copies. Supplies of red line printing paper, under the designation Admel R90/11, are obtainable from Lawes Rabjohns Ltd, Abbey House, Victoria Street, London, S.W.1. On request, this company will supply a specimen print on the R90/11 paper.

Bonding Adhesive

RECENTLY, a new adhesive has been added to the range produced by CIBA (A.R.L.) Ltd, of Duxford, Cambridge. It is termed Redux 68, and has been specifically developed for bonding all types of friction materials required to operate at bond interface temperatures of over 350 deg C. This new adhesive is also capable of filling gaps of up to 0·05 in between components without appreciable reduction in strength. The manufacturers claim that, because of these properties, the adhesive is suitable for applications in heavy transport and public service vehicles of various types.

Controlled Finishing by Vibration

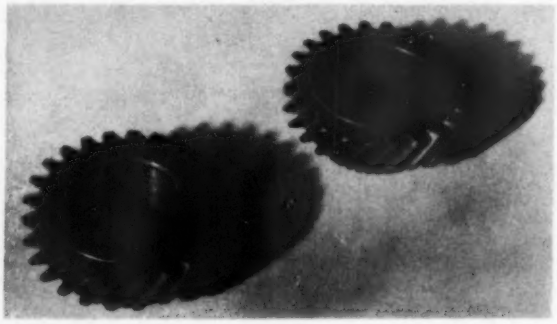
New Process Reduces Cycle Time in the Mass Treatment of Small Parts

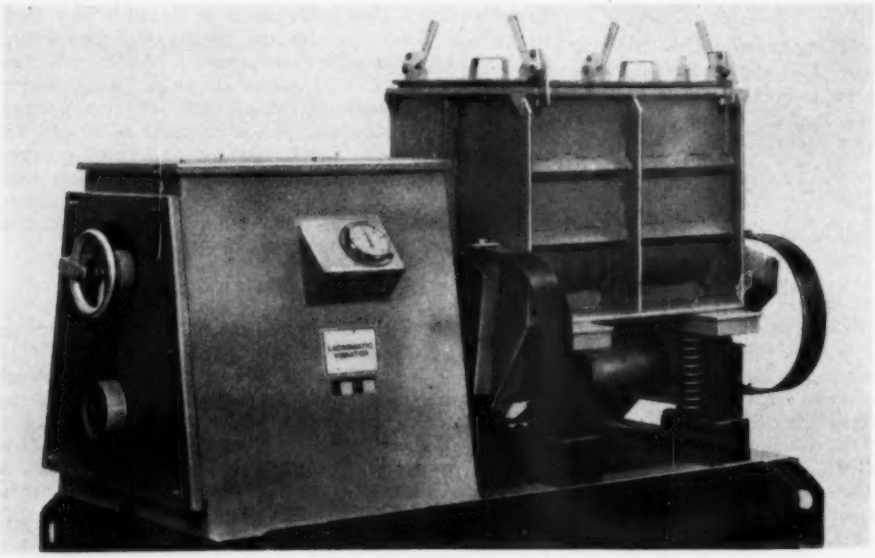
THE process known as barrelling grew from a crude but effective practice of medieval craftsmen, wherein metal parts to be deburred or burnished were mixed with pebbles, sand and water, and rotated in a wine cask by hand. Precision barrelling, as known today, is, of course, done in horizontally mounted rubber-lined octagonal barrels, and the precise nature of the chips and compound that are mixed with the parts is determined as a result of experience and careful experiment. Even though the barrelling process affords a great saving in time relative to manual and other methods of deburring and finishing, one of the drawbacks is the fact that only approximately a tenth of the contents of the barrel is undergoing useful work at any one time, since the cascading or tumbling effect is taking place only at the surface of the mixture in the barrel. In addition to this, barrelling, while being suitable for deburring, polishing, plating, burnishing and various abrasive operations, can normally do only one of these things at a time; changes of finish require changes of mixture and barrelling speed.

Recently, a further step has been made in the progress in respect of this type of finishing. In an attempt both to overcome the limitations just outlined, and to increase the degree of control over the process, Carl Kurt Walther, G.m.b.H, of Germany, has developed the "Trowal-Vibrator", in which parts for processing are mixed with compound and water and placed in a container. Instead of being rotated, however, the parts are vibrated at high speed in a U-section trough where movement is elliptical rather than reciprocal. The result is that the parts and chips rotate very slowly through the trough while they are vibrating against one another, and consequently the whole of the mixture is doing useful work all the time. This means that the time a component spends in the process is only a fraction of what it would be in the case of barrelling.

Several advantages, in addition to the time saving, are immediately apparent. The likelihood of intricately shaped components becoming entangled is reduced, the absence of any cascading movement obviates risk of impact damage to small or delicate parts, and all motion is mechanically induced rather than dependent on the force of gravity. Further to this, parts that normally cannot be processed in a barrel, or processed only with great difficulty, can in many instances be readily finished in a vibrator.

An example of this last category is the case of steel stampings that need sharp edges removed but require a good surface finish. In the conventional machines, a low barrelling speed is called for because rapid barrelling would cause these parts to damage each other during contact. Therefore, in this case, the treatment is a long one. In the vibrator, much harsher treatment can be afforded, without fear of damaging the components, and the time of processing is reduced by a very wide margin. The vibrator is supplied with a control panel which automatically switches the machine off after a selected interval of time, and a reversing switch is incorporated for use mainly when components are mounted on a jig and it is deemed expedient to reverse the direction of flow to ensure uniform processing. The





Above: Helical gears before and after a 45 minute deburring process

Left: The TA1-150 Lacromatic Vibrator, of 5·3 ft³ capacity, with motor and variable speed mechanism

U-section trough is rubber-lined and mounted on springs on which it vibrates freely. The elliptical vibratory motion is imparted by an out-of-balance shaft driven by a variable-speed motor. Adaptability of the vibrator to modern production techniques would appear to be good, for unlike a barrelling machine, the feed and discharge stations are always in the same positions.

A fully automatic adaptation is also available, in which chips and parts are fed into the high end of a tilted trough so that they gravitate to the lower end, to fall on to a vibrating screen that separates the parts from the chips. Then the chips are returned on a conveyor belt for re-processing. The machine is marketed in this country under the name Lacromatic Vibrator, and is manufactured by the Hockley Chemical Company Limited, Hockley Hill, Birmingham 18, who are also the sole selling agents. Sample processing of parts is offered at the demonstration workshop of Lacrinoid Products Limited, Gidea Park, Essex.

Stamped parts before and after processing. The two requirements of good surface finish and removal of all sharp edges were met in one operation, and absence of any tumbling action obviated the risk of contact damage

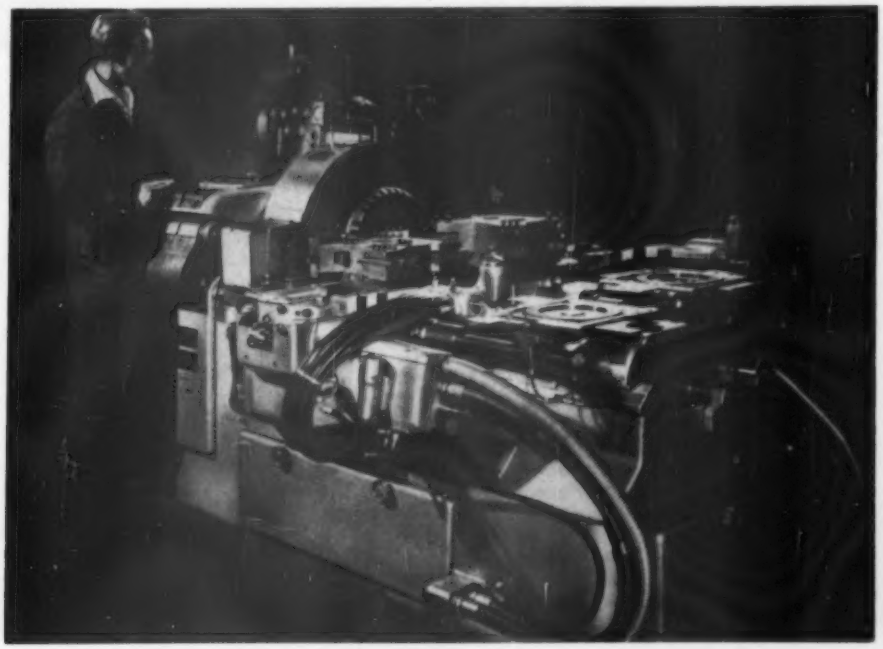
LIECHTI CHUCKING AUTOMATIC

A Swiss-built Machine with Pneumo-hydraulic Operation Controlled by a Steel Programme Band

THIS machine was specially designed and developed for the rapid production of such relatively large and complicated components as flywheels, brake drums or discs, wheelheads, and similar items. By reason of its rigid construction and the provision of ample power—from 31 to 84 h.p. can be arranged—it is capable of rapid metal removal by multiple tooling operating at high feed rates. A driving motor of 42 h.p. is recommended if full use is to be made of sintered carbide tools. There are two completely independent turret slides, each having four indexing stations, and each furnished with copying equipment. Liechti and Co. Ltd, Langnau, Berne, Switzerland, are the makers.

All movements are hydraulically actuated under pneumatic control. Pressure air for control is supplied from a built-in compressor which feeds air to a reservoir to ensure a supply at constant pressure. The compressor unit is cooled from the cutting coolant service. Movements are programmed for automatic operation by means of a punched, strip steel band. Rivets inserted in position in the lines of punched holes operate a bank of valves sequentially to give the automatic cycle required. Each control valve is also manually operable, when setting the machine and whenever desired. These valves allow air to be applied to various pneumatic switches which control the selection of speeds and feeds, operation of the brake coupling and other functions. Each indexing impulse steps the band to bring another row of rivets into position to commence another series of functions. These impulses are initiated by signals received from five different mechanical functions:

(1) The coupling, when full rotational speed has been reached
(2) The spindle, when the brake has been stopped
(3) Indexing, when the tables are located at their stations



A Liechti chucking automatic with steel-band programming equipment, set up for machining 14¾ in diameter flywheels for diesel engines

(4) Stops on the copy tables, actuated by the lead screw
(5) Stops for each cross slide.

The machine has completely independent front and rear tool tables mounted on slides with longitudinal, transverse, and 35 deg angular movements. The transverse slides are connected to the lead screw by a rack; when the rack and lead screw are engaged an angular movement is obtained. Each of the tables may be indexed to four stations, thus in a complete cycle eight different stations can be brought into operation. Attached to the rear of each table is a copy arm carrying a stylus. During copying operations the stylus is guided by a template mounted on a table that indexes simultaneously with its respective tool table.

Illustrated is a Liechti machine, powered by a 45 h.p. motor, in the Perkins Engine plant at Eastfield, Peterborough. It is tooled to machine the 14¼ in diameter cast iron flywheel for the P4/192Y engine which is fitted to the Ferguson F.E. 65 tractor. This component presents a machining problem since the thirty integral cooling vanes cause the heavy roughing cuts to be interrupted. Roughing cuts of from ½ in to ⅝ in and finishing cuts of 0·015 in are regularly taken satisfactorily in routine production. Obviously, the tooling layout avoids the coincidence of roughing and finishing cuts in the cycle.

The sequence of operations on this component follows:

Station 1 Front: Rough clutch face. Rough face from 11⅛ in diameter to 12¼ in diameter

Station 1 Rear: Rough bore 11⅛ in diameter and 12¼ in diameter. (Simultaneous with Station 1 Front)

Station 2 Front: Plunge face end of boss, chamfer, and turn 2⅜ in diameter bore. Face bottom of oil well, finish face 11⅛ in diameter to 12¼ in diameter

Station 2 Rear: Taper bore 10 deg oil-well diameter. (Simultaneous with Station 2 Front)

Station 3 Front: Finish bore 6⅜ in diameter oil-well bore, semi-finish 1·5746-1·5738 in diameter

Station 3 Rear: Finish bore 12·750-12·753 in diameter. Finish bore 11⅛ in diameter

Station 4 Front: Finish clutch face.

Station 4 Rear: Finish bore and chamfer 1·5746-1·5738 in diameter.

The floor-to-floor time is 13·7 min. This compares with a floor-to-floor time of 21 min for the component when previously it was machined on a conventional turret lathe.

Transistorized Ignition System

A TRANSISTORIZED ignition system has been developed by Performance Equipment Co. Ltd.—well known for its engine tuning kits for standard production cars — in collaboration with its associated company, Control Instruments Ltd. The aim in evolving this new equipment has been improved performance together with an even higher standard of reliability and durability than is given by a conventional ignition system. A special form of heavy-duty transistor is used that permits an unusually rapid rate of voltage rise, and hence a much more intense spark than is given by normal equipment.

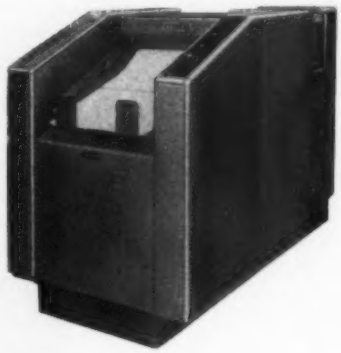
Since the contact breaker is in the input circuit to the transistor, which functions as a relay, it has to carry only the small signal, or triggering current, of about 60 milliamps. The transistor steps up the current to the value necessary for the operation of the coil. Because of the low value of the current carried by the contact breaker, it is claimed that pitting and burning of the points is eliminated. It follows that not only is the life of the points increased enormously, but also the accuracy of timing is retained over a much longer period. The manufacturers state that these mechanical and electrical improvements have a markedly beneficial effect on performance and fuel consumption.

This is a development of which more is likely to be heard. Preparations are now being made for the production of the ignition system, which has been extensively tested during the past 18 months or more on about 20 different cars. The intention is to market a conversion kit, costing £4 to £5, for existing vehicles, but Performance Equipment Co. is naturally desirous of interesting vehicle manufacturers in adopting the system as original equipment.

Printing from Microfilm

THE Ozalid Co. Ltd. has introduced a new machine, the Ozafax Model 19, for producing prints from unperforated 35 mm microfilm, mounted on standard aperture cards. This equipment delivers clean, well defined copies measuring 18 × 24 in or 12 × 18 in. It is considered that these two sizes will be adequate for the majority of drawings prepared in engineering offices, provided that due allowance is made by the draughtsman for the inevitable limitations of the microfilming technique.

The reproduction paper used, which is relatively inexpensive, has a photo-conductive coating, and is automatically sensitized in the machine by the induction of a negative electrostatic charge. Exposure to the film is effected automatically by electronic flash. The light dissipates the charge from the areas not shadowed by the projected image. Then the paper, with its latent electrostatic image, is transferred to the development section of the apparatus, which contains positively charged particles suspended in a non-toxic, non-inflammable liquid. These charged particles migrate to the latent image and adhere permanently to it. Finally, the completed prints are cut to size on emerging on to the delivery tray; since surplus developer is removed from the prints as they leave the development section, no subsequent drying is necessary.



The Ozafax Model 19 produces clear prints from 35 mm microfilm. An output of six per minute is obtainable

Once the operator has verified that the machine contains sufficient of the reproduction paper for his requirements, it is only necessary for him to load the film cards into the feed hopper, set the controls to give the appropriate number of copies from each, and switch on. Thereafter, the operation of the machine is entirely automatic. The rate of output is six copies a minute, and after each film card has been exposed for the desired number of times, it is passed to a receiving hopper.

The Ozafax Model 19 has overall dimensions of 6 ft long × 3 ft 6 in wide × 3 ft 9 in high. Enquiries regarding it should be forwarded to the Ozalid Co. Ltd, Langston Road, Loughton, Essex, or to the company's London sales office, the address of which is 48 Holborn Viaduct, E.C.1.

COATING THICKNESS GAUGE

A Small, Portable, Self-contained Instrument for Checking the Thickness of Paint or Sprayed-metal Coatings on Ferrous Base Material

IN spite of the exercise of all reasonable care in the application of protective or decorative coatings on ferrous metal products, it is desirable to have available means of checking finished work to ensure that any inadvertent lowering of production standards will quickly be detected. Similar considerations apply to the examination of products or component parts received from suppliers, for conformity with specification before accepting and passing the parts into stock. This small electronic instrument, designed by a division of Imperial Chemical Industries Limited, and manufactured and marketed by Solus-Schall Limited, County Building, Honeypot Lane, Stanmore, Middlesex, is specifically intended for such duties.

It provides a high-speed "accept" or "reject" check for any paint or sprayed-metal coatings on a ferro-magnetic base material. Being battery operated it is fully portable, and the overall dimensions, $3\frac{1}{2}$ in $\times 5\frac{1}{2}$ in $\times 1\frac{1}{2}$ in, enable it to be carried conveniently in the pocket of the inspector's overall. The instrument is fully transistorized and the miniature battery has been proved by laboratory tests to have an effective life of from four to six months. It comprises a high-frequency generator, a trigger circuit, an audio-frequency oscillator, and a loudspeaker.

A probe, fitted with a three-point, ball-bearing, face pad is connected to the generator by a cable, three feet in length. The ball bearings obviate wear on the probe and are conducive to easy and rapid movement of the probe over the surface being tested. In the face of the probe there is a coil, the impedance of which will vary with changes in the thickness of the coating immediately below. The coil is in series with the trigger circuit which is activated when the impedance passes a pre-set threshold value. When this happens, the trigger circuit feeds a signal to the audio-frequency oscillator, which in turn feeds the loud speaker.

Battery-operated, transistorized gauge for checking paint or metal coatings

A small and self-contained instrument, the gauge is convenient in use

The setting operation of the unit is quite simple. Two blocks of steel are used for calibration. One carries a coating of correct thickness whilst a thin coating has been applied to the other. The probe is placed first on one and then on the other block. A screwdriver-operated control on the top of the generator is turned so that when the probe rests on the coating of correct thickness there is no sound emitted but when it is placed on the thin coating an audible signal, a loud bleep, is produced.

Once set for a specific duty, the instrument is ready for use. As the probe is moved rapidly over the surface to be tested, any areas of thin coating are quickly detected and defined by means of a loud and persistent noise from the speaker unit. Typical applications of the gauge are for checking the thickness of paint layers on steel body panels for automobiles, of anti-corrosion paint on process tanks and pressure vessels, and of sprayed aluminium or other metals on similar steel surfaces. The extreme portability of the instrument makes it possible to check protective coatings on either indoor or outdoor plant or equipment.

Aluminium Welding Alloy

A COMPLEX paste compound, AutoChemic 990, gives high-strength, corrosion-resistant joints on virtually all types of aluminium alloys. It requires no filler and no after treatment. The compound is painted on where required, facilitating pre-placement on production joining applications. Neat fillets, easily cleaned in warm water, are produced by applying the compound and heating indirectly. A series of chain-type reactions takes place terminating in metallic reduction at the reaction temperature of 400 deg C.

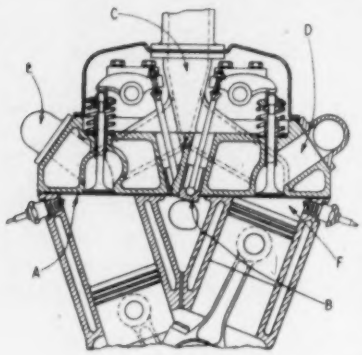
Further information is available from Eutectic Welding Alloys Co. Ltd, Trading Estate, Faggs Road, Feltham.

CURRENT PATENTS

A REVIEW OF RECENT AUTOMOBILE SPECIFICATIONS

Narrow angle vee engine

This overhead valve engine design has two banks of cylinders disposed in a vee, but sharing a common cylinder head and gasket A. The upper surface of the cylinder block and the mating face of the head are plane, and valves are vertical. Therefore, the combustion spaces F are bounded by the flat face of the head, part of the bore, and the piston crown.



No. 850129

The camshaft, carried in the block, is between the banks of cylinders and just below the cylinder head, so that the tappets B slide in bores machined in the head. Thus, the push rods are fully contained within the head assembly. As with other high camshaft designs, removal of the head assembly will not affect timing. The inlet manifold C is integral with the head and centrally disposed between the valve rocker assemblies, and the exhaust ports D run out to external manifolds E. *Patent No.* 850129. *Austin Motor Co. Ltd.*

Plastics body construction for a commercial vehicle

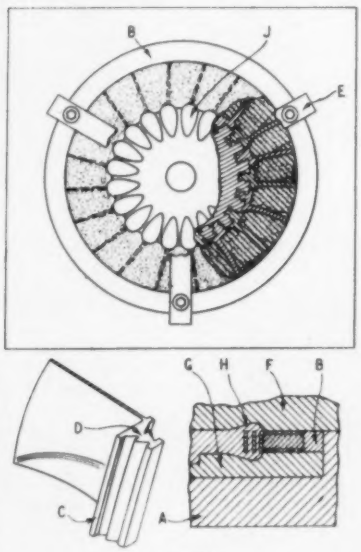
Several methods of constructing a commercial vehicle body in which floor and walls are formed integrally are described in this specification. Sandwich-type construction is used throughout, wherein low density material is interposed between two layers of synthetic resin bonded glass fibres. Either of two processes of construction can be employed: both begin with the building up of one of the layers on a male or female former, as expedient.

In one process, the low density material is applied, in either preformed sheets or strips, to the first layer while the resin is still tacky, after which the second layer is added to complete the sandwich. Alternatively, in the other process the second layer is also made up on a former, the shape being such that a hollow shell is formed when the two layers are brought together; the sandwich is completed by the introduction of synthetic resin and a foaming agent into the spaces between the layers.

Variants of low density material are specified, including cork, foamed plastics material and expanded rubber. Additionally, there are materials that can be made up into a honeycomb structure, and laid in a manner such that the cells are normal to the outer layers; some of these cells can be filled, at least locally, with synthetic resin to form pillars between the layers. Provision is made for reinforcements: these can be placed between the two layers, or built into the outer layer at points of high loading, or added externally in the form of ribs and stiffening members. The synthetic resin used is of the cold curing polyester or epoxy type, with abrasion resistant grit mixed in where required, and the fibrous material is a chopped strand mat. *Patent No.* 849982. *Mickleover Transport Ltd.*

Turbine rotor manufacture

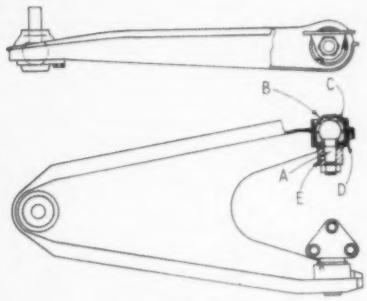
There are several solutions to the problem of securing individually machined turbine blades accurately and positively to the disc of a turbine or compressor wheel. In one which has recently been patented the blades are first rigidly fixed in a disposition corresponding to their final positions on the finished wheel. The disc blank, at forging temperature, is pressed in so that metal flows into the spaces between the roots of the blades. Surplus metal may then be removed by machining.



No. 850209

A die block A encloses a locating ring B, within which is laid the circle of blades. The root of each blade is of fir-tree configuration, and the faces C and ends D are ground to close tolerances to form a register for accurate location so that a complete ring of blades can be formed. Accurate assembly is further assured by the employment of a temporary centring disc placed within the circle of blade roots, and clamping plates E hold the assembly together. Then, molten metal of low melting point is poured into the annulus bounded by ring B, so that when the metal solidifies, the blades become rigidly secured in their correct positions.

The forging operation takes place between two dies F and G, in each of which are bath-tub shape depressions H equal in number to the turbine blades. These depressions are aligned with the spaces between the blade roots so that, under the action of a press, the metal of the preheated disc blank is forced both radially and axially into these spaces, to ensure that complete filling is obtained. After this forging operation, the low melting point metal is run out, and the wedge shape protrusions J created by the flow of metal into the depressions H may be machined off. An integral turbine rotor has thus been formed, using ordinary labour and facilities. *Patent No.* 850209. *Ford Motor Co. Ltd.*



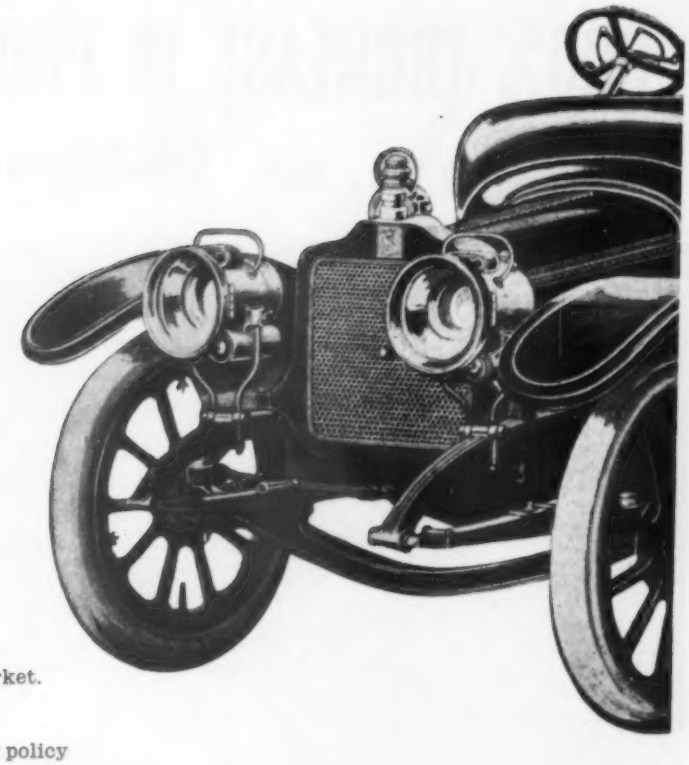
No. 850630

Ball mounting of wishbones

The orthodox method of mounting road wheels on wishbones can lead to problems which arise from twisting of the vehicle frame. The resultant lack of alignment can cause jamming of the wishbone inner bearings. Incorporation of rubber is not a complete solution, for rubber bushes allow a relatively small angle of movement and, further to this, their restoring moment can be troublesome. The specification proposes the use of ball and socket joints.

In a typical wishbone, the ball stud A is secured to a mounting bracket E which in turn is bolted to the vehicle frame. The bearing bushes C, are contained in a casing B, which is pressed into a sleeve in the wishbone. Each end of the sleeve is crimped over in three places D to retain the assembly. Synthetic material is specified for bushes C, so that service attention and the transmission of vibrations are reduced to a minimum.

A symmetrical variant of this ball and socket arrangement is also described, in which the ball stud is replaced by a spherically-surfaced sleeve, through which passes a bolt supported at each end by a bifurcated frame bracket. *Patent No.* 850630. *Viktor Langen (Germany).*



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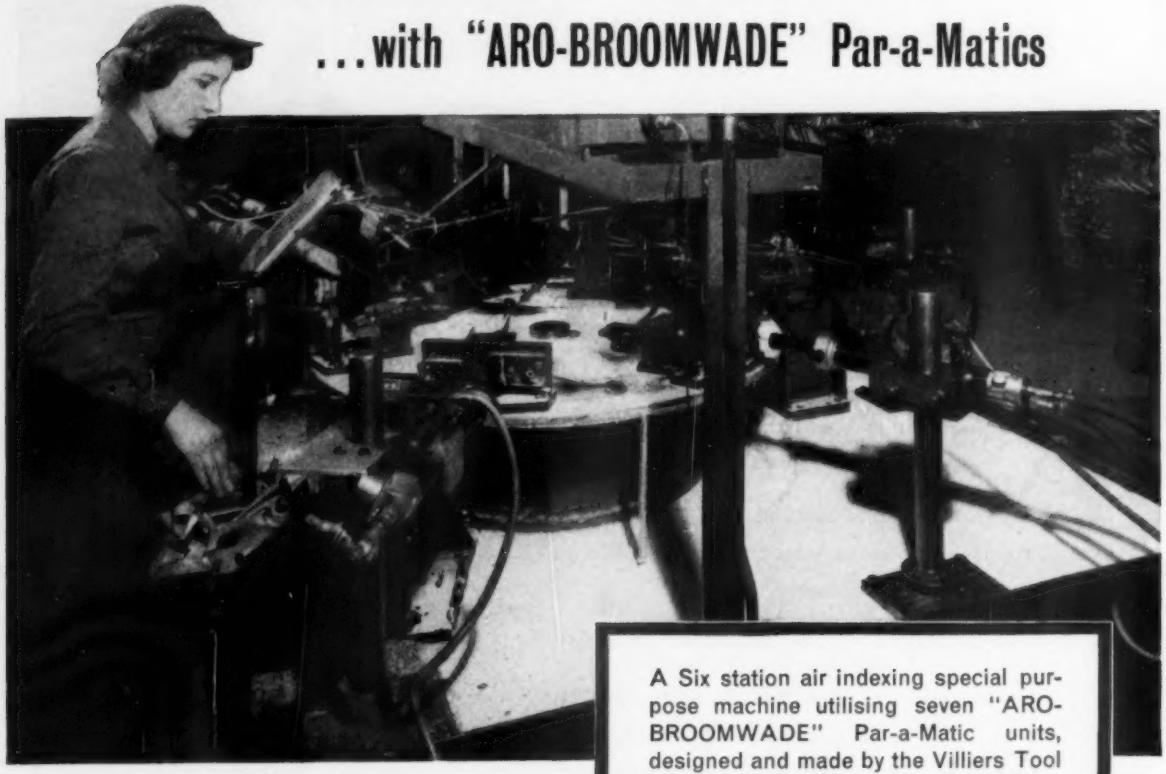

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This machine carries out the following sequence of operations at a *production rate of 150 per hour. Previous methods produced only 200 per day.*

1st Station—Drill 2 holes for u.n.f. tapping.

2nd Station—Tap 2 holes 10 u.n.f.

3rd Station—Drill 2 holes for 6 BA Tapping (Multi-head).

4th Station—Tap 1 hole 6 BA.

5th Station—Tap 1 hole 6 BA.

6th Station—Unload fixture and load fresh component.

Special note should be made of the 2 spindle drilling head attached to the PAR-A-MATIC for drilling the 2 close spaced holes at Station No. 3.

Photograph by courtesy of Messrs. Fry's Diecastings Ltd.

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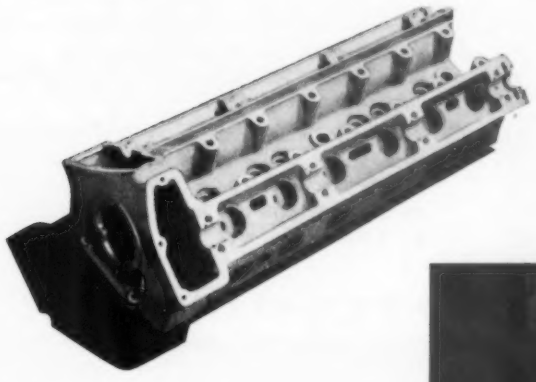

For many years, William Mills have supplied aluminium castings for the cylinder heads, sumps and manifolds of Jaguar cars. The range of Mark 2 models, introduced for 1960, uses similar castings in LM4 alloy, and the intricate cylinder head casting shown is a fine example of modern foundry technique.

Aluminium alloy castings by

William Mills Limited

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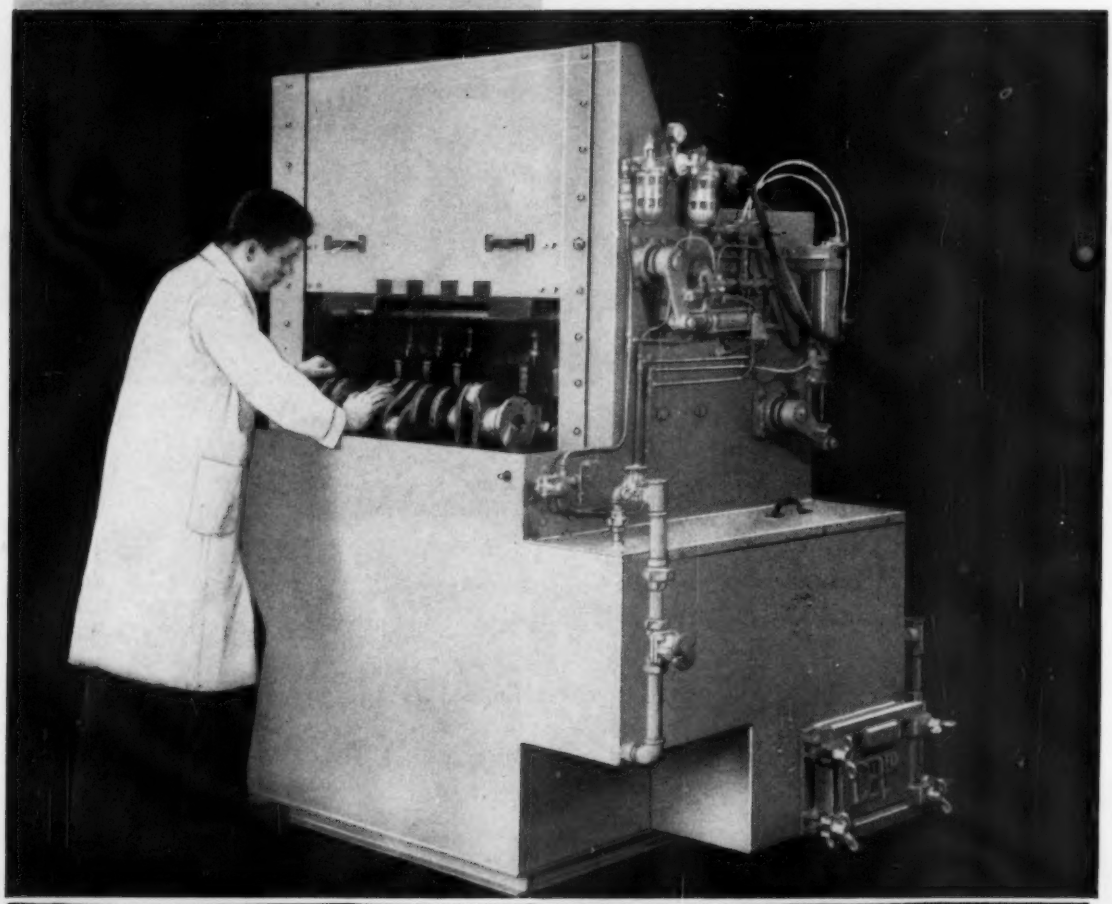
AP132

New Dawson high precision crankshaft washing plant

This is a new cabinet type machine which Dawsons supply to wash all sizes and types of crankshafts. A pneumatically operated carrier lowers the crankshafts into the cleaning position where special jets in the form of upper and lower bearing caps having annular grooves in the internal diameter locate closely on the journals allowing the alkaline solution to be forced through the oilways in the journals and out through the crank pins. At the same time jet pipes above and below thoroughly wash the external surfaces of the shafts.

The machine illustrated handles up to 20 crankshafts per hour, and is also available as an "In-line" machine, loading at one end and discharging at the other. "In-line" machines are available to handle up to 120 crankshafts per hour.

FULLY PROTECTED BY PATENTS



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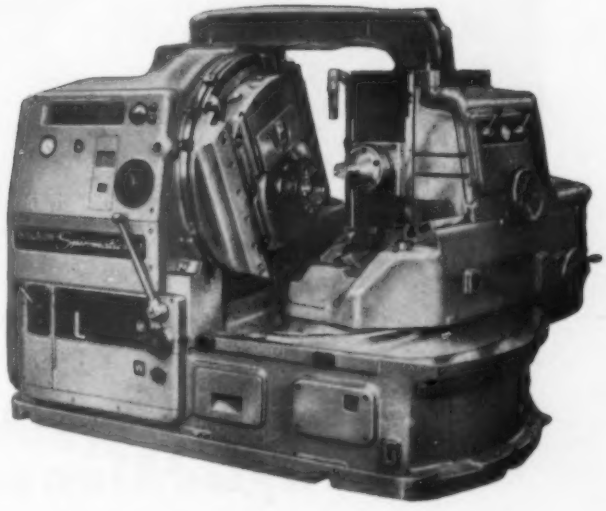

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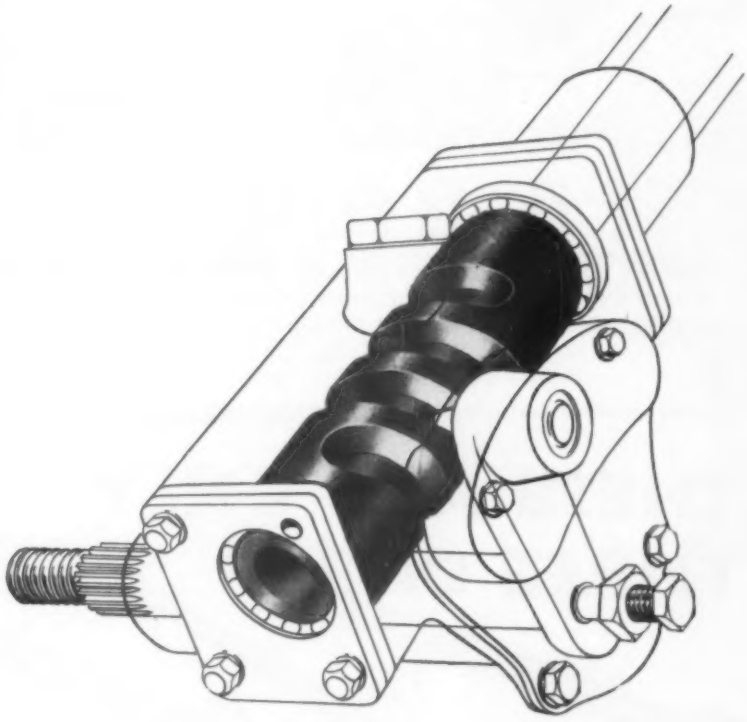

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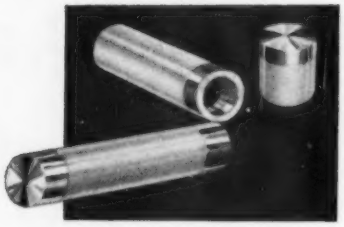

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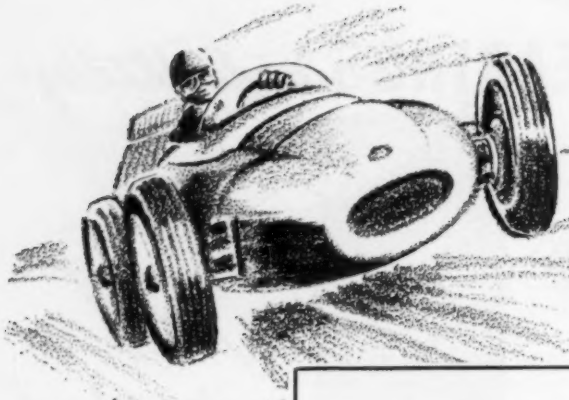

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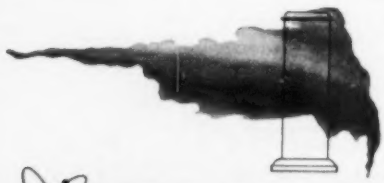
The liquefaction of gases is an important branch of low temperature physics. Its importance is stressed by the fact that, of recent years, increasing use has been made in both industry and science of liquefied gases, such as oxygen, nitrogen, helium and hydrogen.

In the automobile industry new methods of increasing the flow of production are constantly being sought. One such method, involving the use of liquid oxygen, or nitrogen, is involved in the term "Shrinkage Fits". This denotes a process of freeze-shrinking the shaft or insert by immersion in either of these liquefied gases, down to minus 185/196°C. The simplicity of such a process, combined with its saving of many hours, gives it a considerable advantage over more traditional methods.



Here, at Dupree Swift, we make the spherical copper high-vacuum container (above right) for storage of liquid oxygen or nitrogen, and the cylindrical, or soaker type (left), for immersion of the insert, as stated above, in either of these liquefied gases.

Our catalogue will tell you more about our products— just write or telephone.

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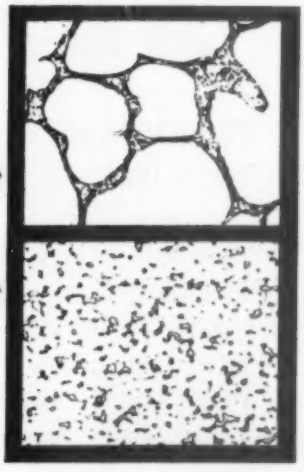
Reticular tin-aluminium, as bonded to steel for high load-carrying capacity engine bearings, is an aluminium alloy, containing 20% tin and 1% copper, worked and heat-treated so that the tin is continuous only along grain edges, but not along grain faces, as is the case when this alloy is in the "as cast" condition. Working and heat-treatment enable the aluminium grains to bond into a continuous aluminium phase whilst the tin, although not distributed over the grain faces, is still a continuous network structure.



Micrograph of aluminium — 20% tin, as cast.

Micrograph of aluminium — 20% tin, rolled and annealed.

The latest development in Plain Bearings, defined above in technical terms, offers manufacturers and private motorists—

New standard of load-carrying capacity.
Exceptional life.
Compatibility with conventional crankshaft materials.
Resistance to corrosion attacks.

It has now been adopted by—
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Our licencees, TRIONE of Turin, supply FIAT and S.A.M.E. (Fratelli Cassani).

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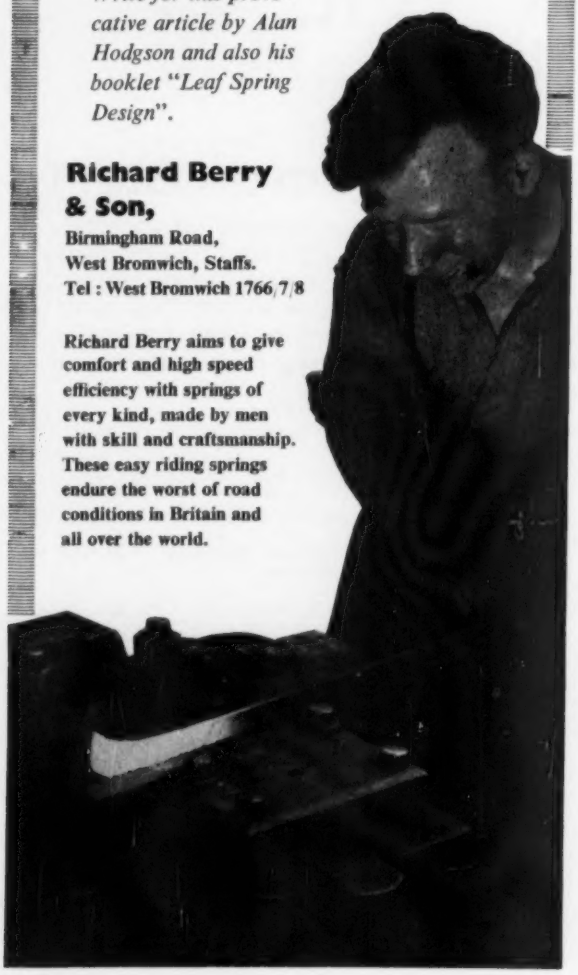
Richard Berry aims to give comfort and high speed efficiency with springs of every kind, made by men with skill and craftsmanship. These easy riding springs endure the worst of road conditions in Britain and all over the world.



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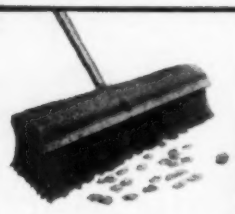
Placing lock washers on screws takes time—costs money.
SEMS eliminate this.

With SEMS the washer and screw are supplied as a manufactured unit, cut handling, assembly costs.



With SEMS, washers are held on by the screw's rolled threads. Washer losses are eliminated.

SEMS washers fit closer under head, tapered twisted teeth lock tighter.

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SHAKEPROOF THREAD CUTTING SCREW
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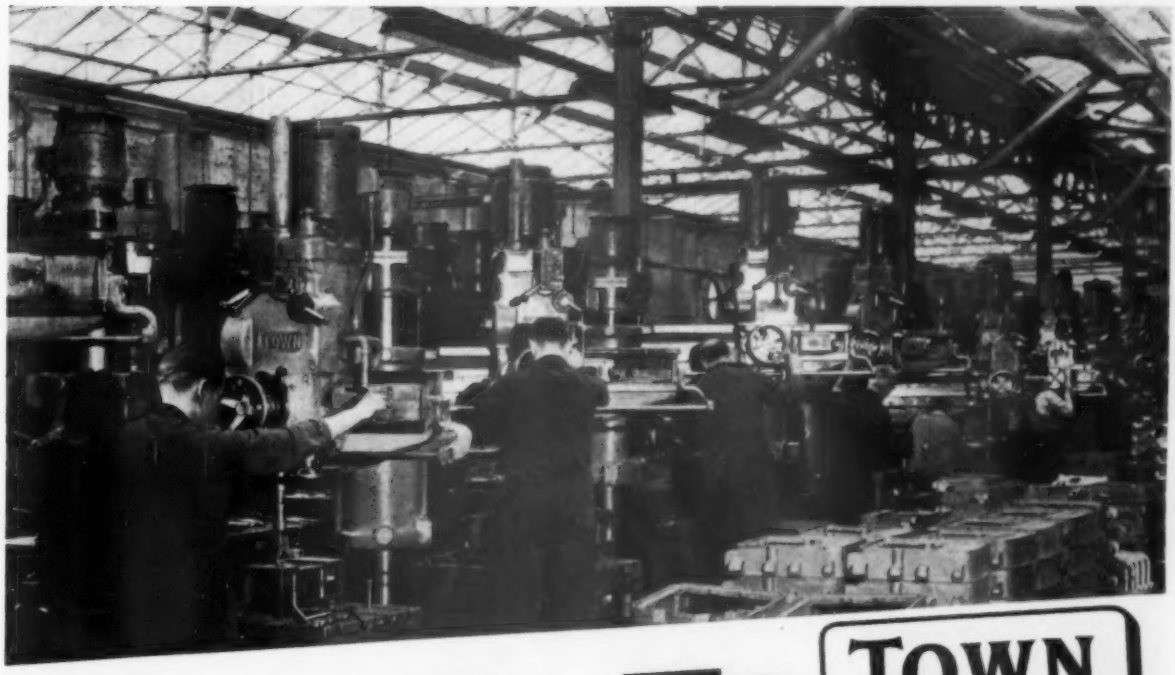

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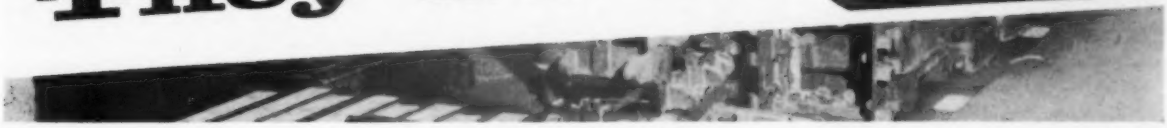

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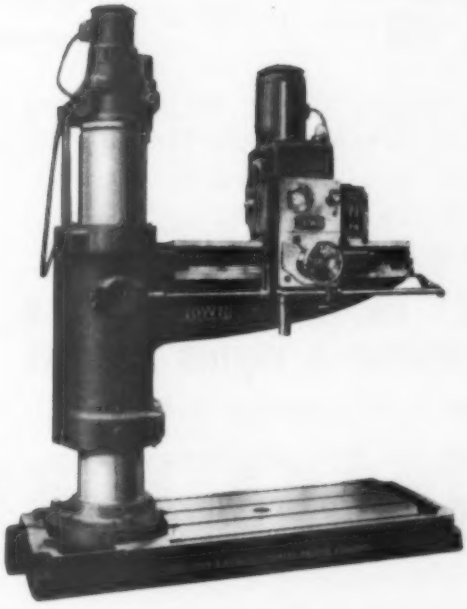

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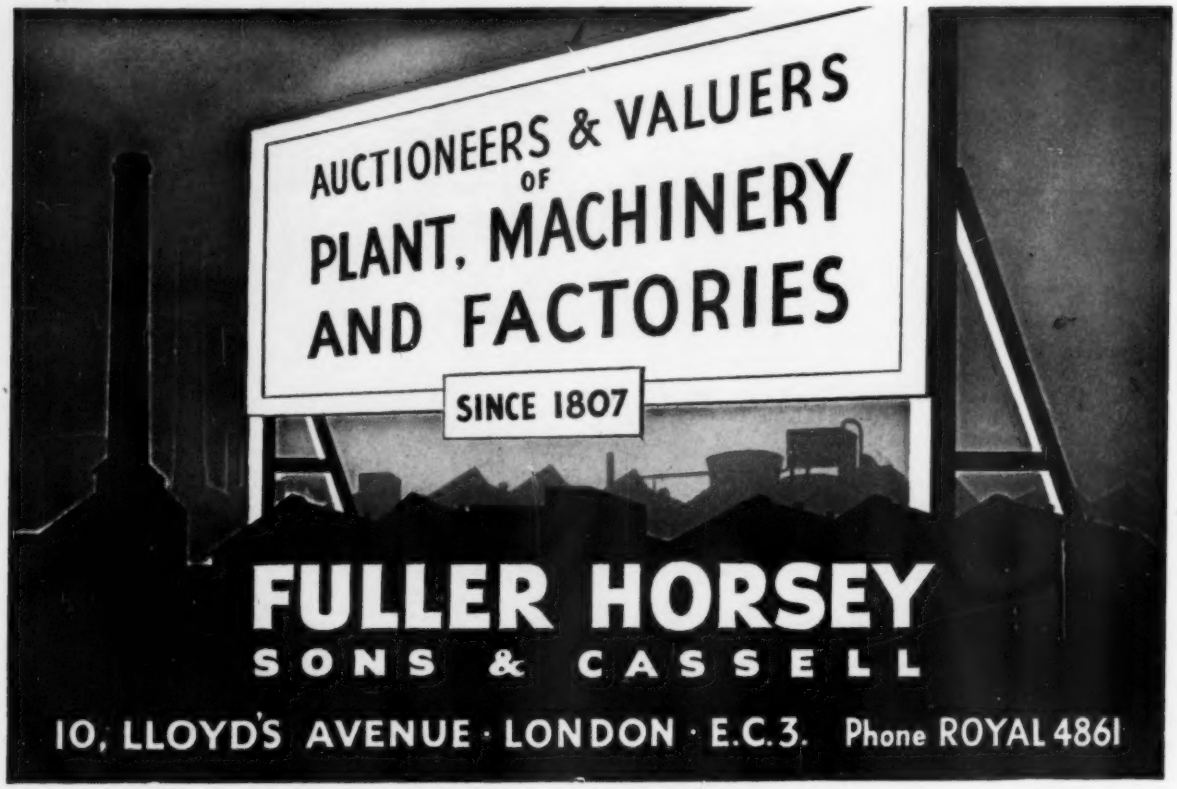

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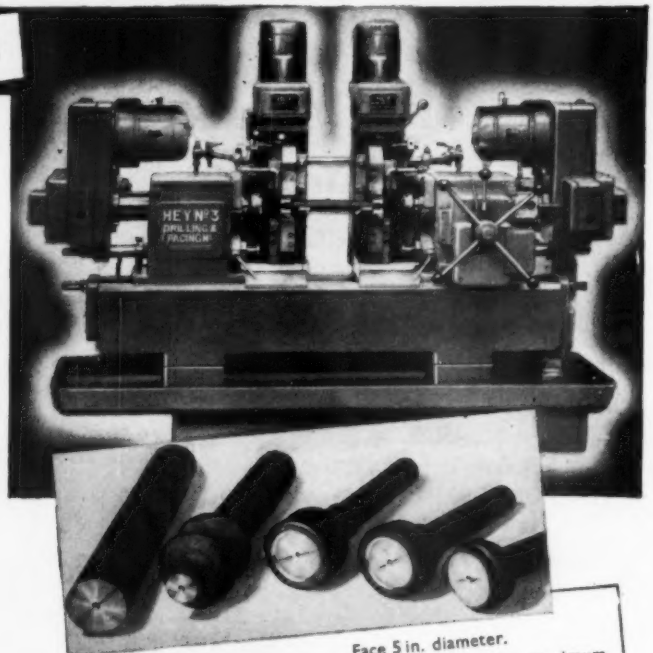

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The Tandem Master Cylinder operates the hydraulic systems to front and rear axles independently, and therefore provides a safety factor in the event of failure in either of the two circuits.

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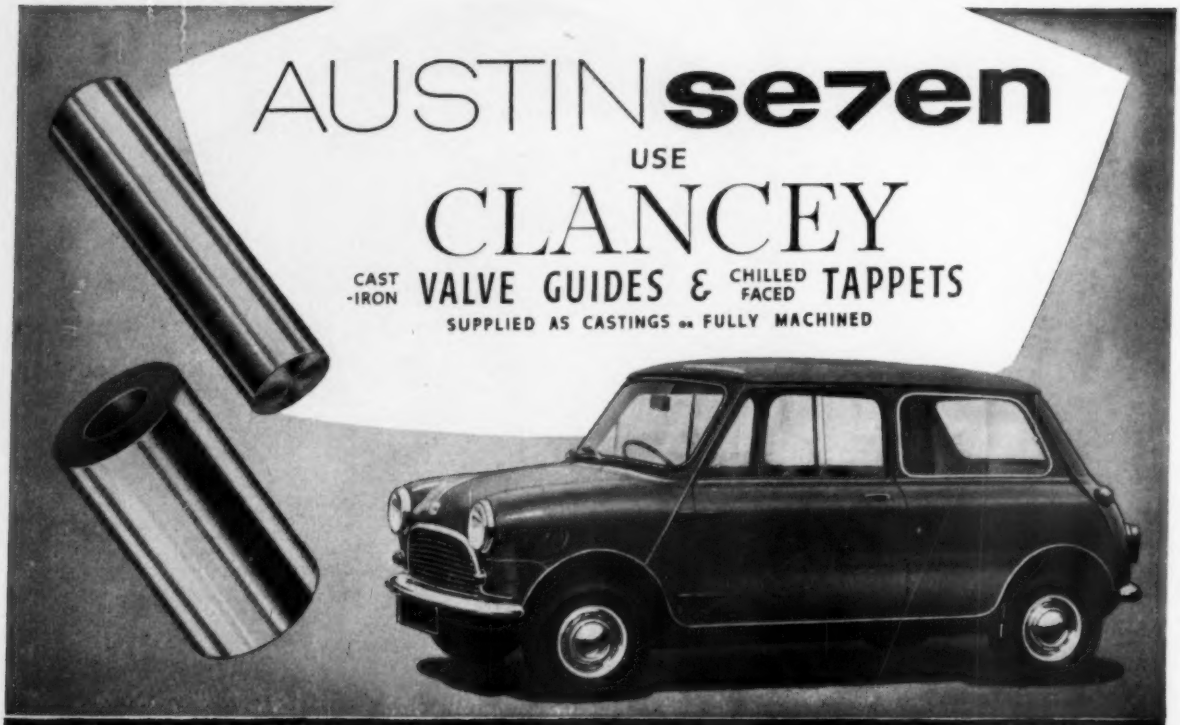

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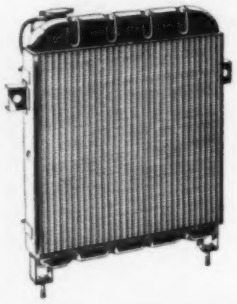

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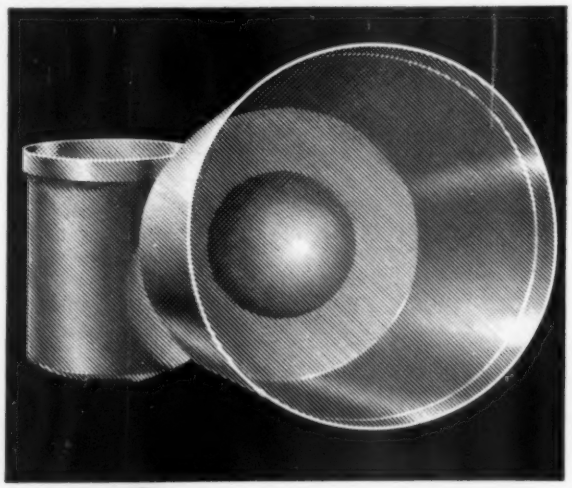

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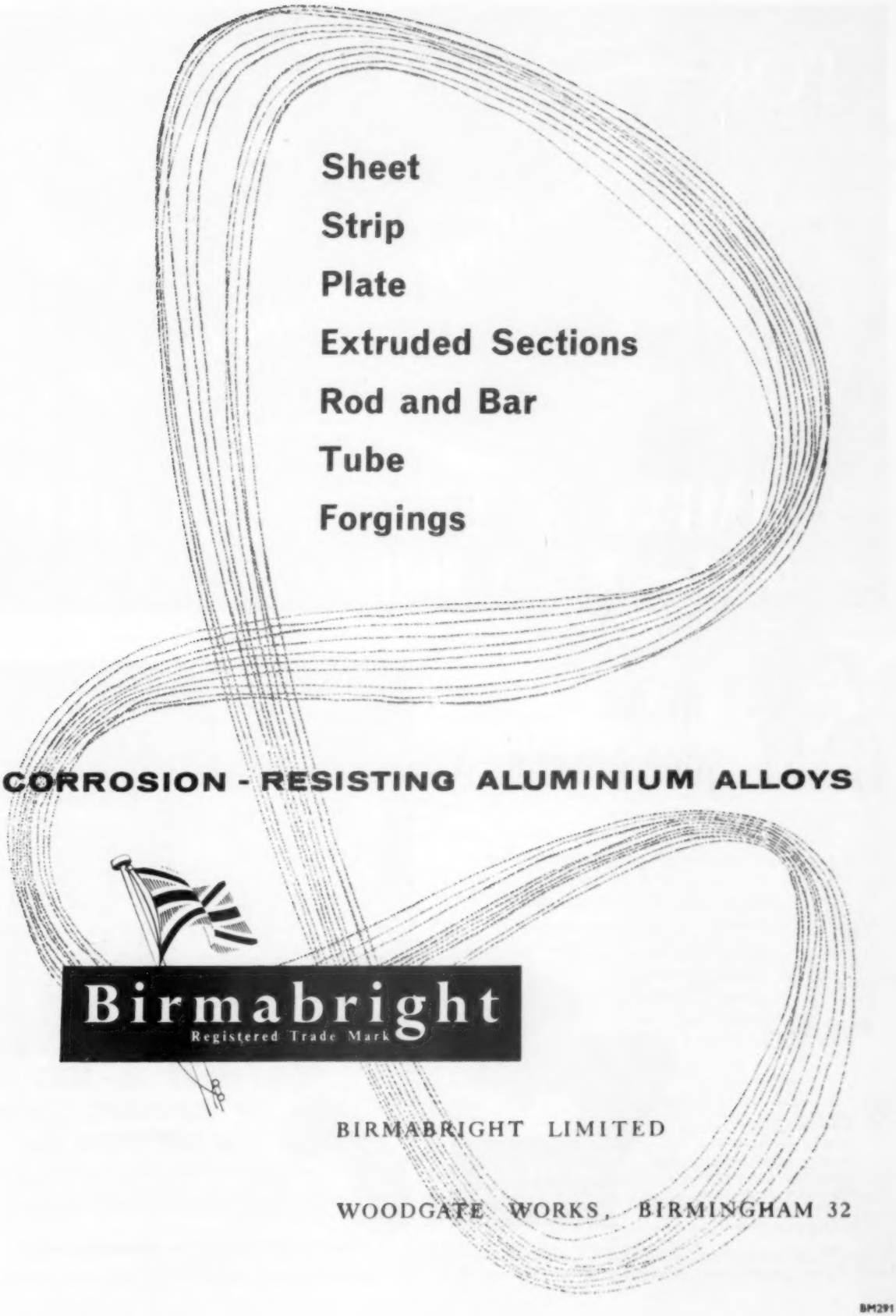
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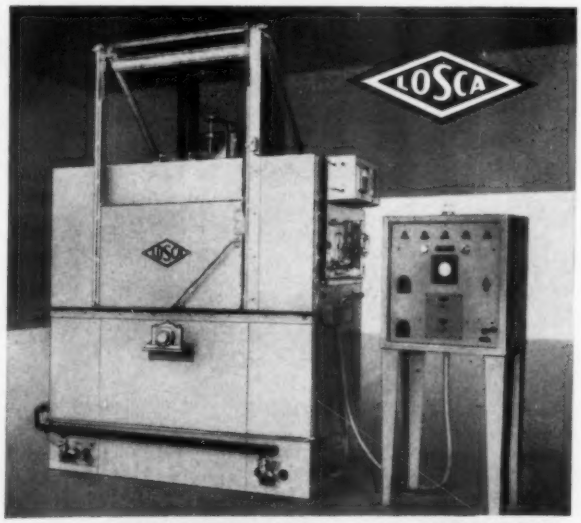

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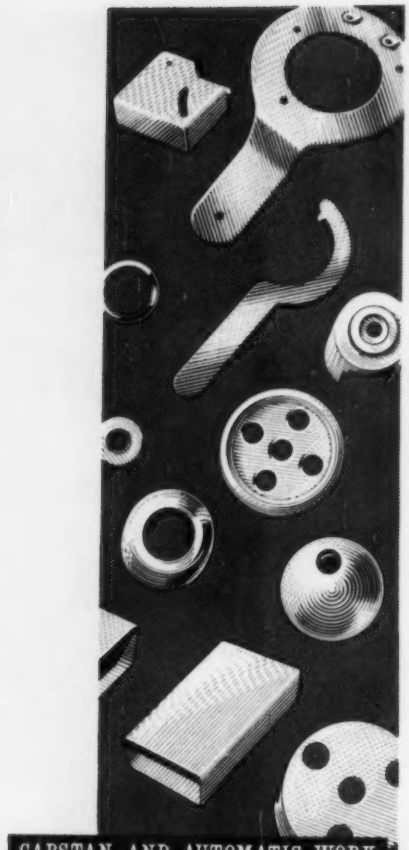

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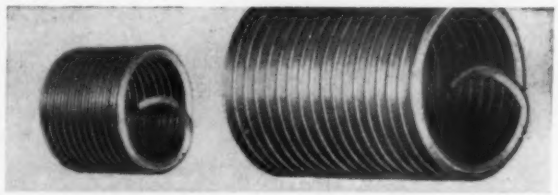

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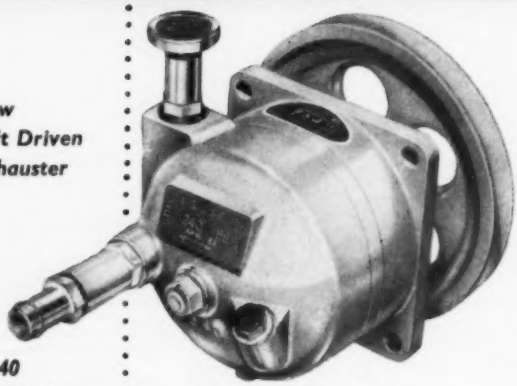

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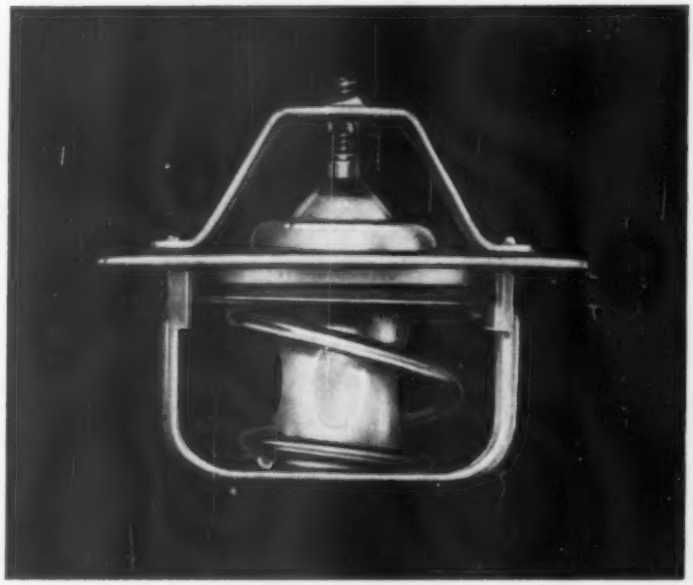

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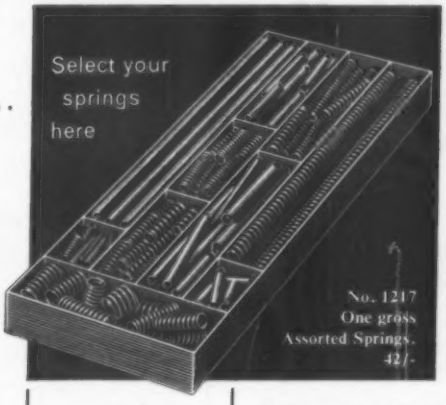

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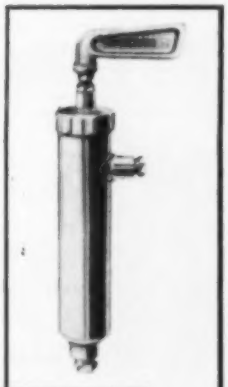

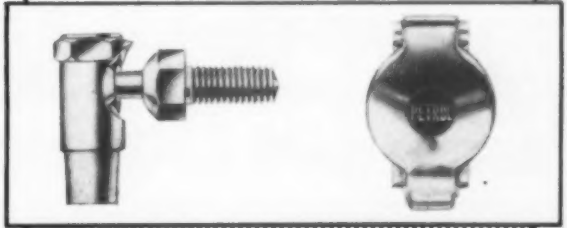

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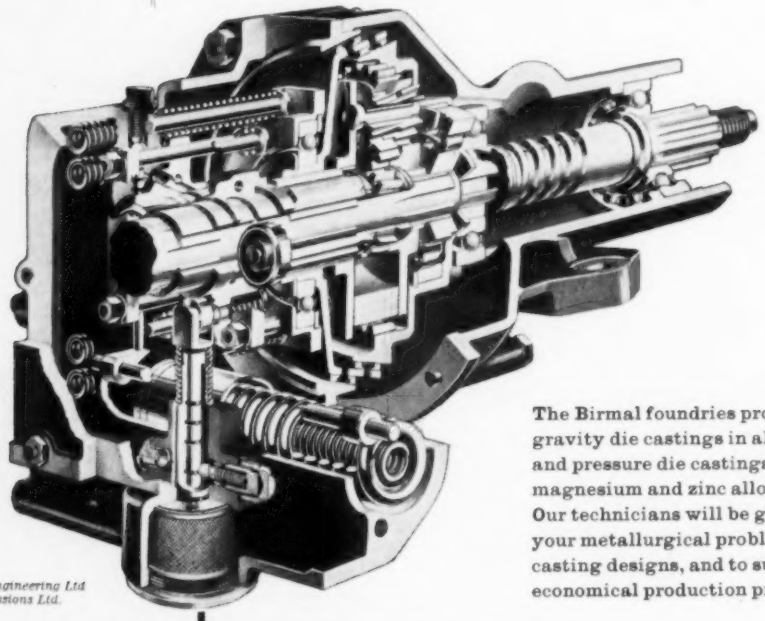

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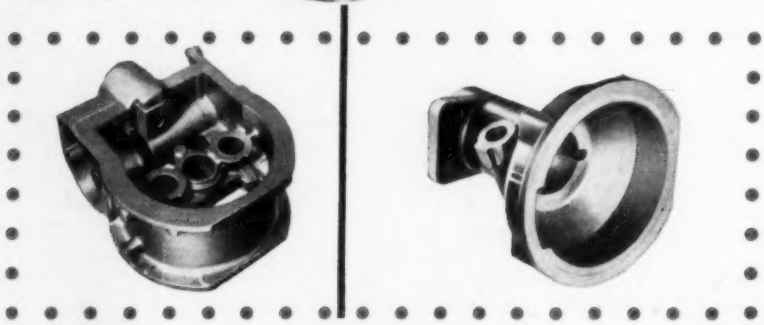

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